# AN ABSTRACT OF THE THESIS OF

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Terrence Beaumariage

This thesis is intended to provide the management of small to medium sized job shop companies with a written plan to implement a formal computerized manufacturing planning and control system. The research stemmed from a case study performed at a typical job shop where growth of production activities was complicating the informal control system being used. A review of the literature and a survey of job shops provided the necessary foundation for this implementation. Research indicated that typical material requirements planning (MRP) systems do not provide the type of shop floor control that most job shops require. This thesis suggests alternatives that not only provide the type of shop floor control required by a typical job shop, but software that can be managed effectively by current employees with minimal changes to the education and training of these employees.

The plan contains ten steps that are designed to be used by a job shop wishing to implement a formal computerized control system. A decision making heuristic is used in the first step that provides a method for estimating the benefits that might result from implementation. Sample criteria for evaluating current shop floor control software, development of an implementation timeline, cost considerations, educational requirements for employees, and suggested methods for measuring project performance

are also included. Examples of the type of improvement that can be expected for each of the business activities is also discussed.

The overall goal is to provide a comprehensive plan that will guide managers through the steps necessary to implement a computerized shop floor control system and to inform managers of the benefits which can accrue from such a system.

# Planning and Implementing a Manufacturing Control System in a Job Shop Environment

by

Robert N. Maplestone

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Redacted for Privacy

Major Professor, representing Industrial Engineering

Redacted for Privacy

Chair of Department of Industrial and Manufacturing Engineering

Redacted for Privacy

Dean of Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

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Robert N. Maplestone, Author

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## 1. Introduction

The original motivation for this thesis stemmed from a project/case study performed during the summer of 1995 for S & R Industries [1], located in Baker City, Oregon. To help assess their production management methods, S & R Industries approached Oregon State University's (OSU) Industrial and Manufacturing Engineering Department with the hope that better control could be attained. After spending considerable time at the plant, it became apparent that S & R would not benefit from implementing standard material requirements planning (MRP), but master production scheduling (MPS) and manufacturing planning control (MPC) techniques could significantly improve their manufacturing performance especially if used in conjunction with a computerized control system.

Using a computerized control package, S & R Industries would be able to prepare accurate quotes based on capacity of the plant in general, but more importantly, based on the capacity of each work center. Knowledge of the capacity of each work center and the scheduling options available through the use of this data would provide for overall improved delivery performance.

S & R Industries was interested in estimating more effectively using past job history and current work center capacity estimates. In addition, they were looking for improved performance in areas including: inventory control, scheduling, materials control, and purchasing.

A typical small fabrication job shop producing medium and heavy structural products with sales of $3.5 million (1995), S & R employs 40 production personnel. The production facilities comprise 25,000 square feet of floor space with overhead lifting capabilities of 20 tons. Typical equipment used at S & R includes burning and cutting equipment, machine tools, welding, finishing, and painting facilities. A repetitively manufactured wood chipping machine product line is produced in a section of the plant using a flow type manual production line. This line produces approximately 250 Chippers per year, 6% of S & R's total sales dollars. An IMAC product line is produced on contract through IMAC Canada, a Canadian manufacturing company located in Edmonton, Alberta. S & R produces a full line of IMAC products which are typically blades, buckets, and attachments for heavy equipment. Current sales in this area are 22%. A general fabrication section handles all other products and involves the manufacture and sometimes the design of contract parts and sub-assemblies and accounts for 54% of current sales. Industrial field installation services are also provided by S & R to install products manufactured by S & R or products produced by other manufacturers. This service currently accounts for 18% of sales.

Based on observations made at the S & R plant, it was estimated that many other job shop companies were in a similar position. S & R knew that they could improve what they were doing, but they were not sure how to achieve their goal. With their tight production schedule and high work load it was difficult for personnel to take time to research their options. When the project at S & R was finished, a closer look at job shops in general was undertaken. It was the intent that they too could benefit from the standardized architecture suggested for S & R.

Currently there are over 36,000 [2] job shops in the United States (U.S.). Over 4,000 of these job shops employ between 20 and 49 employees and generate total annual sales of over $14 billion. These job shops play a vital role in the United States manufacturing system by producing complex detail parts and assemblies for many larger U.S. manufacturers who sell products globally. The Boeing Company, for example, relies on hundreds of job shops to supply many parts for its final assembly plants throughout the country according to Jim Whitman [3], Boeing industrial analyst.

Larger companies are becoming subject to increased global competition, increased need for continuous improvement, and are often registered in organizations such as ISO9000. Many require their subcontractors to seek registration in ISO9000, which assess processes used in product design and production. Larger companies often produce vast quantities of products and rely on formal methods to control their systems and deliver parts using JIT methods. This control is typically performed by individuals who specialize in MRP, MPS, and shop floor control (SFC). Many of these individuals are engineers or technicians who have received formal education in these areas.

In smaller companies, ones that typically employ less than 50 people, it is very difficult for management to allocate the manpower and resources necessary for individuals to specialize in each of these areas. Often, small companies get by with the use of very informal control methods. As these companies expand and increase both product sales and manpower, it becomes more and more difficult to manage these activities informally. As the quantity of end items increases and the number of detail parts that need tracking increases, the informal control system often breaks down. Also, the need for implementing JIT systems to serve their customers has led to shorter lead times, smaller lot sizes, more setups, more schedule changes and more day-to-day shop floor activities, Beard [4]. It is then necessary for these smaller companies to look at formal control methods.

Global competition, ISO9000, tight profit margins, and the need for continuous quality improvement have all pushed control of manufacturing organizations to a higher level. The need for manufacturing control has never been greater. Job shops who refuse to take formal structured control of their production systems will find themselves losing customers to other job shops who are able to implement computerized manufacturing control. Only by adapting to the needs of their customers will job shops be viable into the future.

Software systems are currently available that will allow these smaller manufacturing companies to achieve this control. However, the major problem facing these smaller companies is the required allocation of manpower and resources necessary to critically review their current manufacturing control system and research the available computerized control software packages. Choosing and implementing these systems can be a major headache, and requires many hours of planning to achieve a smooth transition from the current system to a new formal control system.

With the initial investment necessary to implement this type of computerized system decreasing each year, current costs for suitable computer network systems and the software necessary to control production data are now lower than they have ever been. The payback period for investing in this type of control system is typically extremely short. JobBOSS [5] estimates a payback that averages two years. Further research and a survey of job shops confirmed this hypothesis: many small job shop manufacturers can benefit from the application of a standardized architecture and approach to production planning and control implementation.

# 2. Problem Definition and Background

To gain a better understanding of job shops in general and to more closely review the methods and similarities between these shops and those of S & R Industries, a review of current literature and a formal job shop survey was performed. The intent was to use the data and methods outlined in the S & R project and apply these, where appropriate, to other job shops in general. A survey (shown on pages 6-7) was sent to all job shop companies listed in the American Business Disk [6] that employed between 20 and 49 employees and were located in Washington or Oregon. Results from this survey indicated that: the average annual sales for these companies was \$3.6 million, and that they employed an average of 38 employees of which 76% were shop floor employees and 10% were shop floor managers. There were 132 companies total and the response was ten percent. The survey looked at two major topic areas, the first related to the shop floor control (SFC) and the use of computerized verses paper systems, and the second related to the education and training that shop floor employees had received in these areas. The questions about SFC asked the respondents to indicate if they used a computer or a paper system for control. The results varied based on the area in question; 66% used computers for scheduling, 58% for capacity planning, 78% for inventory control, 69% for raw materials control, 69% used a shop router/traveler, 55% used MRP and 40% used MPS. The questions about education asked employers to identify their training source for each area listed above. The overall response indicted that 10.6% received their training from a college course, 8.6% from vendor training, and 80.8% received no formal training. The complete survey results can be found on pages 8-10. The data from the survey lead to a review of current literature with the intent that a plan could be developed to help interested job shops implement a formal control system.

**Manufacturing Shop Floor Control Survey**

Company Name: ______________________________ Phone: _______________

Address: ________________________________________________________

Estimated Annual Sales $ ______________

Your Name: _________________________ Your Title: _____________________

What percentage of your production is:

Job Shop Production _______ % Proprietary Product Production _______ %

Indicate the percentage of shop equipment that is:

CNC _________ % Conventional _________ %

Estimated Number of Shop Floor Employees: _________

Estimated Number of Total Employees: _________

Estimated Number of Employees that Manage Production on the Shop Floor. _______

Please indicate any formal education that the above management employees have received related to shop floor control. Indicate the number of employees under the appropriate heading:

| | College Course | Vendor Training | No Formal Training |
|---|---|---|---|
| Scheduling | number _____ | number ______ | number ________ |
| Capacity Planning | number _____ | number ______ | number ________ |
| Inventory Control | number _____ | number ______ | number ________ |
| Material Req. Plan.(MRP) | number _____ | number ______ | number ________ |
| Master Prod. Sche(MPS) | number _____ | number ______ | number ________ |

Figure 1. Survey Form

Please indicate the primary method that your company uses to perform each of the functions defined below:

| | Computer Generated | Manually Generated | Not Formally Done |
|---|---|---|---|
| Scheduling | | | |
| Capacity Planning | | | |
| Inventory Control | | | |
| Raw Materials Control | | | |
| Shop Router/Traveler | | | |
| Labor Time Reporting | | | |
| Purchase Orders | | | |
| Package/Shipping Slips | | | |
| Receiving | | | |
| Job Quoting | | | |
| Billing | | | |
| MRP | | | |
| MPS | | | |

What best describes your company's position regarding computerized shop floor control:
Currently used: _____ Currently used but need more training: _____

Have plans to use: _____ Interested but have no plans: _____ Not interested: _____

Would it be acceptable for me to call you if I have any questions? Yes: _____ No: _____

Figure 1. continued

| Functions/Response | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Annual Sales In Millions $ | 3.0 | 5.0 | 3.0 | 4.5 | 3.0 | | 2.0 | 4.0 |
| Job Shop Production % | 100 | | 100 | 99 | 80 | 100 | 0 | 10 |
| Proprietary Production % | 0 | | 0 | 1 | 20 | 0 | 100 | 90 |
| Shop Equipment CNC % | 95 | 90 | 60 | 90 | 0 | 50 | 70 | 10 |
| Shop Equipment Conventional % | 5 | 10 | 40 | 10 | 100 | 50 | 30 | 90 |
| Number of Shop Floor Employees | 30 | 55 | 25 | 34 | 18 | 27 | 14 | 24 |
| Total Number of Employees | 36 | 65 | 35 | 41 | 22 | 37 | 23 | 34 |
| Shop Floor Employees % of Total | 83 | 85 | 71 | 83 | 82 | 73 | 61 | 71 |
| Number of Managers on Shop Floor | 5 | 3 | 3 | 3 | 2 | 1 | 3 | 3 |
| Managers as % of Shop Floor | 17 | 5 | 12 | 9 | 8 | 4 | 21 | 13 |
| Sales per Total number of Employees | 83,333 | 76,923 | 85,715 | 109,756 | 136,364 | | 86,957 | 117,647 |

| Functions/Response | 9 | 10 | 11 | 12 | 13 | Totals | Average |
|---|---|---|---|---|---|---|---|
| Annual Sales In Millions $ | 3.0 | 3.5 | 2.5 | 6.0 | 3.6 | 43.1 | 3.6 |
| Job Shop Production % | 100 | 10 | 100 | 100 | 100 | 899 | 74.9 |
| Proprietary Production % | 0 | 90 | 0 | 0 | 0 | 301 | 25.1 |
| Shop Equipment CNC % | 75 | 0 | 90 | 99 | 20 | 749 | 57.6 |
| Shop Equipment Conventional % | 25 | 100 | 10 | 1 | 80 | 551 | 42.4 |
| Number of Shop Floor Employees | 28 | 30 | 17 | 40 | 39 | 381 | 29.3 |
| Total Number of Employees | 38 | 35 | 29 | 50 | 47 | 492 | 37.8 |
| Shop Floor Employees % of Total | 74 | 86 | 59 | 80 | 83 | 989.6 | 76.1 |
| Number of Managers on Shop Floor | 2 | 2 | 1 | 4 | 4 | 35.5 | 2.7 |
| Managers as % of Shop Floor | 7 | 7 | 6 | 10 | 10 | 128.9 | 9.9 |
| Sales per Total number of Employees | 78.947 | 100,000 | 86,207 | 120,000 | 76,596 | 1,158.444 | 89,111 |

Figure 2. Survey Results

This set of questions asked respondents to:
Please indicate the primary method that your company used to perform each of the functions defined below.

| Functions/Response | Computer Generated | Manually Generated | Not Formally Done |
|---|---|---|---|
| Scheduling | 66% | 33% | 0% |
| Capacity Planning | 58% | 25% | 17% |
| Inventory Control | 78% | 15% | 8% |
| Raw Materials Control | 69% | 23% | 8% |
| Shop Router/Traveler | 69% | 15% | 8% |
| Labor Time Reporting | 75% | 23% | 0% |
| Purchase Orders | 58% | 41% | 0% |
| Packaging/Shipping Slips | 75% | 25% | 0% |
| Receiving | 54% | 50% | 0% |
| Job Quoting | 54% | 46% | 0% |
| Billing | 85% | 15% | 0% |
| MRP | 55% | 9% | 42% |
| MPS | 40% | 10% | 55% |

Figure 2. continued. Note: Not all responses equal 100% and some respondents checked more than one answer or did not respond to all questions.

This set of questions asked respondents to:
Identify the total number of employees in management and indicate what form of training these employees had received in each of the categories listed.

| **Functions/Response** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | Totals | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Employees in Management** | 5 | 3 | 3 | 3 | 1.5 | 1 | 3 | 3 | 2 | 2 | 1 | 4 | 4 | 35.5 | 2.7 |
| **Scheduling** | | | | | | | | | | | | | | | |
| College Course | | | 1 | | | | | 1 | | | | | | 2 | 7% |
| Vendor Training | | | 2 | | | | | | | | | | 1 | 3 | 11% |
| No Formal Training | 5 | | | 3 | 2 | | 3 | 2 | 1 | 2 | 1 | 4 | | 23 | 83% |
| **Capacity Planning** | | | | | | | | | | | | | | | |
| College Course | | | 1 | | | | | 2 | | | | | | 3 | 13% |
| Vendor Training | | | | | | | | | | | | | 1 | 1 | 4% |
| No Formal Training | 5 | | 2 | 3 | | | 2 | | 1 | 2 | 1 | 4 | | 20 | 83% |
| **Inventory Control** | | | | | | | | | | | | | | | |
| College Course | | | 1 | | | | | | | | | | | 1 | 5% |
| Vendor Training | | | | | | | | | 1 | | | | | 1 | 9% |
| No Formal Training | 5 | | 2 | 1 | | | 1 | 3 | | 2 | 1 | 4 | | 19 | 86% |
| **MRP** | | | | | | | | | | | | | | | |
| College Course | | | 1 | | | | | 2 | | | | | | 3 | 14% |
| Vendor Training | | | | | | | | | 1 | | | | 1 | 2 | 10% |
| No Formal Training | 5 | | 2 | | | | 2 | | | 2 | 1 | 4 | | 16 | 76% |
| **MPS** | | | | | | | | | | | | | | | |
| College Course | | | 1 | | | | | 2 | | | | | | 3 | 14% |
| Vendor Training | | | | | | | | | 1 | | | | 1 | 2 | 9% |
| No Formal Training | 5 | | 2 | 2 | | | | | 1 | 2 | 1 | 4 | | 17 | 77% |

Figure 2. continued. Note: Not all responses are complete as some respondents were not consistent, i.e. their responses did not equal the number of management employees.

In a paper titled "Seven Steps to Factory Control", O'Neil [7] states that 70% of all manufacturing companies use computers, but only 30% use manufacturing control systems. He indicates that there are a number of reasons for this and that they include: 1) a lack of understanding of the new technology that is available and the fact that many managers are still waiting for the "ultimate" system, and 2) software suppliers do not provide the right kind of help to move companies through the implementation process indicating that the implementation of an MPC system is a long term process and must be achieved with strategic management planning. He continues by describing the need for long term comprehensive support services and educational support and training both "on and off site". He suggests there should also be some method for monitoring the improvements resulting from the implementation of the new system.

A survey performed by Wisner [8] of over 900 make-to-order machine shops in 1995 (14.6% response) found that one third or less used computers for formal shop floor control. He also concluded that the priority dispatching rules acclaimed in the literature (i.e., shortest processing time and lowest critical ratio) were used less frequently as most shops used simple methods for scheduling, including earliest due date, most important customer and first come first served. Less than 10% of respondents used MRP and little importance was placed on Just-In-Time (JIT) production capabilities and inventory levels indicating that many of the respondents might not be aware of the cost savings and quality advantages associated with JIT production. He also noted a high level of ongoing training as 21% of employees had received over four weeks training annually but indicated that a gap existed between research and the actual practices used for SFC.

When discussing scheduling on the shop floor, Diesslin [9], stresses the need for basic scheduling methods that can incorporate the day to day activities. Scheduling is complex and many complex scheduling algorithms are available, however, the dynamic nature of everyday shop floor activities typically render complex scheduling algorithms useless. Shop floor control personnel must understand how the schedule works if they are to use it effectively, complex algorithms do not help. There appears to be a need for SFC research to more closely relate to everyday machine shop practices. He emphasizes assigning each machine and piece of equipment to a work center and defining work capacity for each work center, including holidays and maintenance downtime. Using an effective process plan/traveler that provides all the critical data, including work centers used and setup and runtime requirements, is very important as the process plan/traveler is the "heart" of the system and is used to formulate the schedule and provide the overall plan for production.

Raza [10] in a paper on "Scheduling for the Real World" states that traditional MRP II systems are designed for conditions that are not ideal and are rarely found in everyday shop floor systems. Raza emphasizes the use of "Finite-Capacity Software" indicating that it can be more effectively used to schedule shop floor activities using the variables that most often occur in everyday activities. He also stresses that finite rather than infinite loading should be used because it uses the capacity that is defined as available rather than loading a work center above its capacity and then using an iterative process to level load the work center.

The sales of MRP and MRP II systems from 1993 to 1994 increased by 40%, with total U.S. sales of the systems reaching $2.8 billion in 1994, LaPlante [11]. He states that the Japanese are fascinated with the U.S. manufacturers love of MRP and MRP II systems and attribute this to the fact that MRP and MRP II are key phrases in manufacturing circles. However, he then goes on to state that the Japanese do not think that these systems provide the information and planning at the shop floor level that is necessary to focus on the customer's needs. The answer is in the use of "completely integrated systems" that tie PC spreadsheets, databases and other systems together. "The idea is fairly simple: focus on what the customer needs, and work backwards from there."

Diesslin [12] makes a strong case for using computers for SFC in machine shops based on the "visibility" that a computerized system provides. He states that most control problems occur because managers and planners are not able to see what is happening on the shop floor. They do not have a clear picture of where each job is, what work has been completed and what work is currently being performed on a job. This visibility can be provided by a computerized module and enhanced with a bar code system that quickly allows personnel to update shop floor data and provide managers and planners real-time information. Diesslin also concludes that "Implementing a shop control module is a slow process which is heavily dependent on good process planning and clear procedures on the shop floor."

When interviewing Tom Allen, Chairman, MESA International, Harkanson [13] describes a new class of software, Manufacturing Execution Systems (MES), that provides the transition between the plan from an MRP II system and actual production. In an interview conducted in Modern Materials Handling, he describes how MRP II software utilizes available resources to develop a schedule and can tell you what was produced after production is complete. However, it is what happens between the MRP II plan and the completion of production that causes most everyday problems, it's this missing piece that MES provides. Allen states that managers must learn to adapt to this "real-time, live, dynamic system in order to realize more efficiency of their operations."

Manufacturing Execution Systems (MES) according to Knill [14] bring the following benefits: a real-time look at the factory floor and the products moving through the system, including the processes being applied. Ongoing real-time record keeping and financial data are available at any time for review, and improved quality and productivity allow market strategies to improve profitability.

Maynard [15] describes another acronym that is becoming used in the MPC systems industry, APET (Advanced Planning Engine Technologies). These are software systems that are being developed to tie the MRP systems to the shop floor and also to other business areas such as shipping, traffic and other capacity constraints. Maynard states "MRP systems couldn't forecast demand or plan production based on capacity. There was no way to feed information from events on the production floor back into a plant's weekly master production schedule, so schedules quickly became inaccurate." Currently APET suppliers are trying to handle the entire manufacturing process and hope to be able to provide control from the receiving of raw materials to the shipping of the finished product.

Other advantages provided by SFC software packages include: the capture of CAD/CAM files, camcorder images, graphics and scanned data that can be displayed on local terminals and connected to a job file. Text and even hand written notes describing setup problems and production information can also be provided, which can improve the learning curve for complex setup and processes, Realtrac [16].

With the data from the job shop survey, the information from current literature and the results from the S & R case study, this thesis was developed.

# 3. S & R Industries Case Study

Examination of the situation at S & R Industries revealed many areas where management was interested in improved shop floor control. They were considering reviewing software systems and had, in fact, looked at one or two. However, this process had stalled due to the lack of resources and an implementation plan. The case study performed at S & R Industries is outlined here.

Based on the fact that little was known about S & R's current production operations, a method that would document what was currently being done at S & R, (i.e. how each department functioned in relationship to the other departments in the plant) was needed. To achieve this, interviews with management and production personnel were conducted and a list of all the activities performed and who performed the activities was created. This led to a plant layout drawing defining each department, its work centers, and their relationship in the plant and a flow chart defining department activities and relationships. The flow chart was created by simply listing the departments in a row across the top of the sheet; Sales, Office, Engineering, Production etc., creating columns for each department, and then listing the functions under each. The departments were then connected with directional arrows describing the flow of information. This flow chart (a section of which is shown in Figure 3 on the next page and the complete flow chart appears in Appendix A) was reviewed with management to verify its accuracy. This chart clearly showed how each of the activities such as sales, purchasing, inventory, and production was related and how information and material flowed from one area to the other. Documenting a system this way, and allowing each member of the production control team to review the current process helps to identify problems and provides an opportunity to recommend improvements.

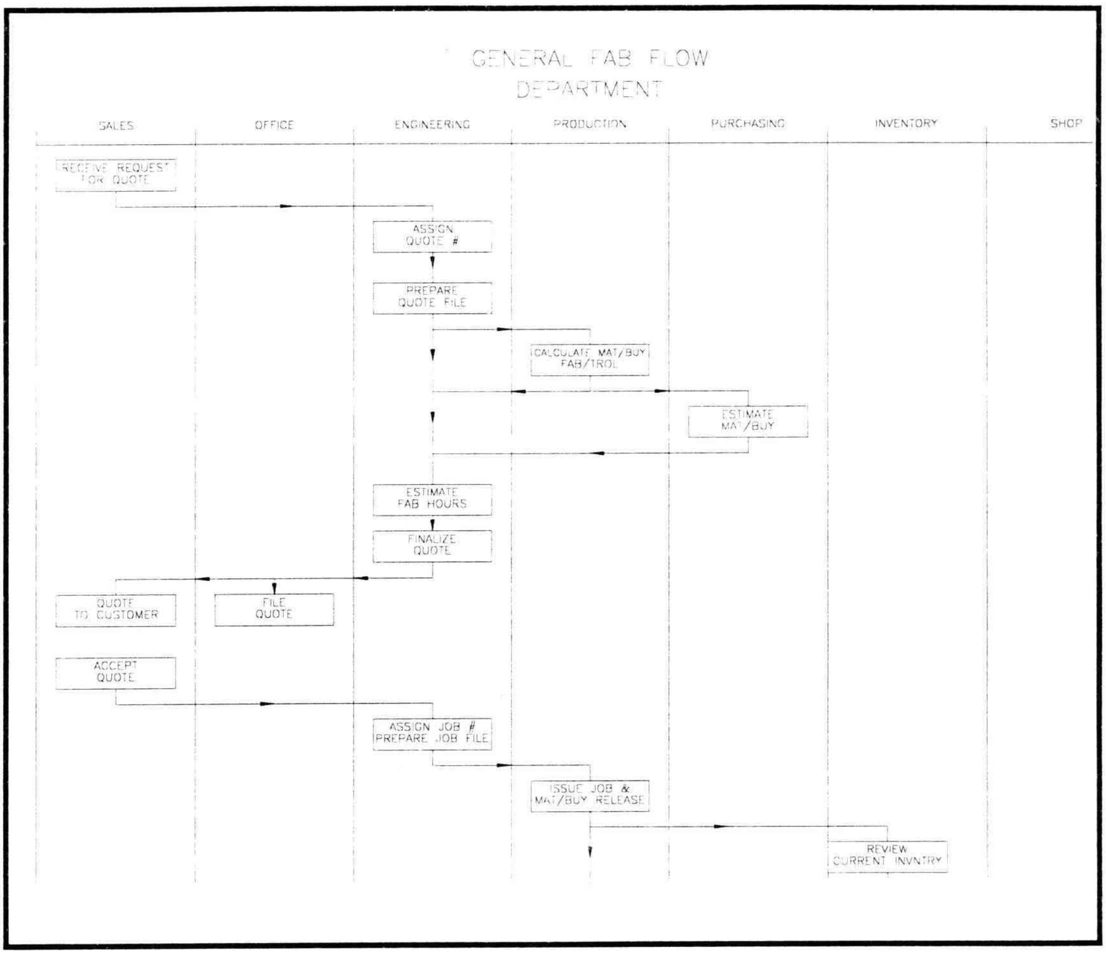


Figure 3. Section of the S & R original flow chart.

From the data collected through interviews with company personnel, a set of problems was developed. These problems were expressed by either management or shop floor personnel and typically related to problems of control of activities or product tracking.

## 3.1 Identified Problems at S & R Industries

After careful review of the current production system and extensive discussion, a set of problems was identified. These problems were analyzed to assist in determining improvements. The problems that were identified at S & R are:

- Current quotes are inconsistent in format and content. Lack of a current standard format for making quotes results in inconsistencies which does not always provide production with the data necessary to effectively process a job.
- There is no method of tracking work center capacity. Quotes are often made without considering work center capacity which leads to over capacity situations that often require overtime. Quoting jobs at standard rates when work centers are working overtime reduces profit.
- It is difficult to access previous quote data for review when quoting similar jobs. The current filing method, for filing quotes, does not allow easy access to previous quotes based on request similarity. This often results in a new quote being made rather than an old quote being modified. In addition, problems encountered with a previous job can be repeated if the problems are not identified when similar jobs are quoted.
- The lack of use of a detailed shop router to adequately define the production process results in engineering spending 20% to 30% of their time in the shop solving production problems. These problems typically require decisions to be made on how a part or job should be processed through the shop.
- The current method used for tracking jobs is only updated once per week which does not allow for effective control of jobs that are completed in less than this time frame.
- There is currently no efficient method used to determine existing material inventory. Material in inventory is determined by physical inspection and is used on a first come basis. This often results in material shortages.

- It is currently difficult to determine when to pay purchase orders (PO's) as there is no efficient method to determine when a PO is complete. Receiving will often accept partial PO's. It later becomes difficult to determine which PO's are complete and need to be paid. There is no efficient method of tracking outstanding PO's.
- There is no current method of tracking lead-times for purchased items. This leads to parts being shipped by more expensive methods than is necessary. Often a part will be ordered and requested to arrive over-night air freight. If the order lead-time for delivery of this part had been known, it could have been ordered earlier and shipped by less expensive methods.
- It is currently difficult for Purchasing to realize quantity discounts when purchasing parts as there is no effective way to review the upcoming job schedule or part history information when ordering parts.
- Planning shipping dates in advance can be very difficult when the schedule is frequently changed. Therefore it is difficult for Purchasing to realize both receiving and shipping transportation discounts. Typically, a truck is ordered when a job is complete. Combined shipments are rarely considered.

From review of the defined problem set, a list of objectives was developed. Again, these objectives were developed with input from both management and shop floor personnel.

## 3.2 Production Control System Objectives

The list of observed problems was presented to and discussed with the production control team. This led to the development of a set of production control system objectives that were then used to outline a control system for S & R Industries. The objectives are:

- Make efficient, accurate quotes based on capacity of the plant in general, but more importantly based on the capacity of each work center.
- Efficiently access previous quotes so that these quotes can be reviewed and possibly modified for future use. This would allow problem jobs to be reviewed so that similar mistakes would not be made.
- Efficiently calculate material requirements for new jobs/parts and store this data for future use on repeat jobs/parts bill of material.
- Accurately track all material and parts in inventory and their location in the plant.
- Determine and track the ordering history for economic order quantities (EOQ) and the lead-times of buyout parts so that Purchasing can order these parts when needed.
- Access previously purchased material and purchased part costs for source reference.
- Efficiently schedule jobs through the shop based on work center capacity, job priority and available labor man-hours.
- Produce an effective shop router (process plan) outlining production requirements so that parts/jobs will flow through the shop more efficiently.
- Prepare accurate shipping documentation in a timely manner.
- Determine what parts/material PO items have been received so that complete PO's can be paid.
- Determine EOQ's based on the planned schedule of upcoming jobs so that price breaks can be realized.
- Access the current status of any job in the plant.
- Review the record of actual times and costs for each job to determine efficiency.

From review of the management objective list it was determined that these objectives could best be achieved with the use of a computerized system. The ability to access real-time data using a computer, compared to using paper methods, could result in a major advantage. In addition, cross referencing of records can greatly increase the usability of job records. To support this, a new flow chart was developed that linked each activity to a database. A section of this flow chart is shown in Figure 4 and the complete chart appears in Appendix B.

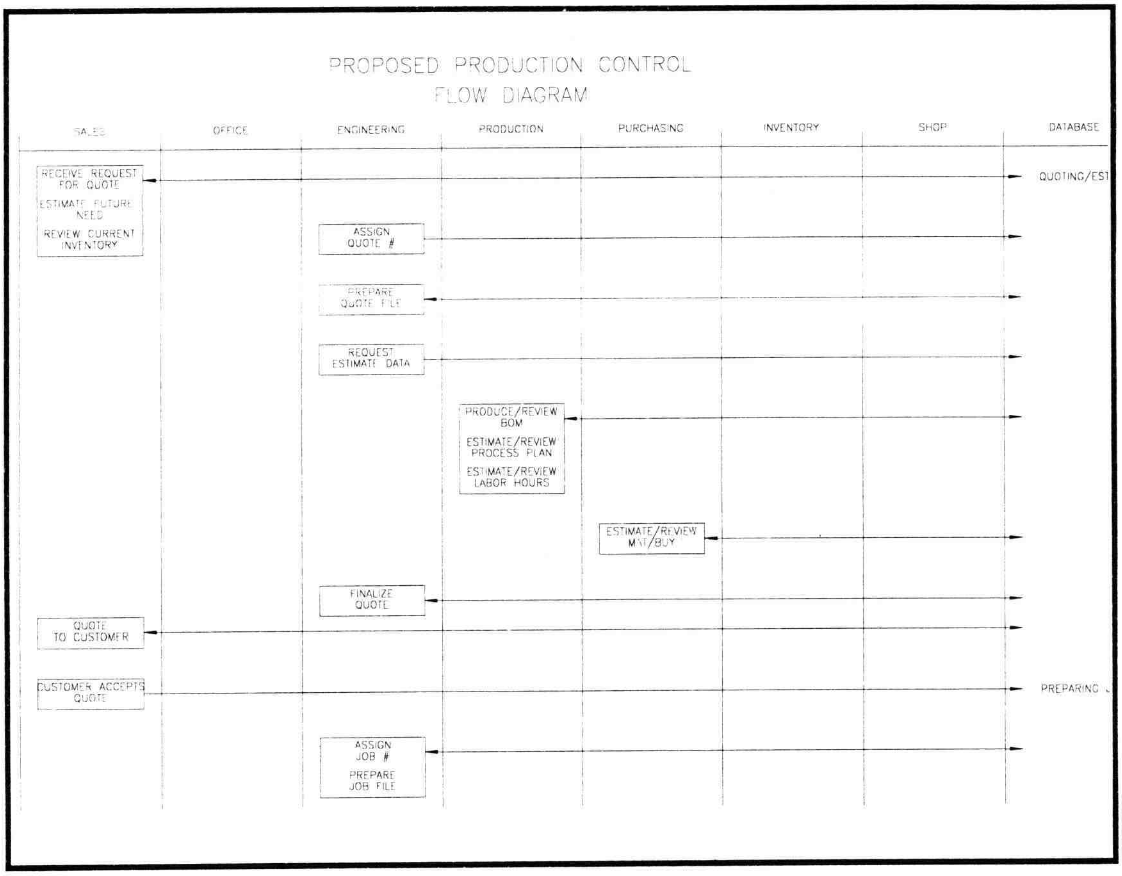


Figure 4. Section of the proposed S & R flow chart.

## 3.3 Possible Benefits Available from Implementing an MPC System

Each of the functions outlined in the proposed S & R control system would be linked together by a computer database. The use of a computerized control system would allow efficient tracking and management of S & R's large numbers of material types and parts.

It would also provide for real-time data access and numerous benefits. Those benefits are listed and described here.

### *3.3.1 Quoting*

Many new jobs that require a quote are similar to previous jobs and could use existing quote data to create a new quote, thereby saving estimating time. Typically, paper filing methods do not make it easy to access data, relying on individuals to remember similarities between previous jobs so that they can review and maybe use or modify existing quotes. Most computerized systems allow access to data by referencing part type, part name, vender name, part number, and production date to identify the similarities between parts. Some computerized systems use group technology methods to simplify this part identification. Once an estimator has identified the similarities between a previous part quote and a new part quote, the advantages are extensive.

A computerized system provides access to all the important information about the existing part or job, including the process plan that defines the processes that were used to produce the part or parts. It provides information on what materials were used, where the materials were purchased, the cost of materials and many other associated data costs. Important data on problems that might have occurred during production, can also be reviewed so that the same mistakes are not repeated. Data on the quoted cost of all facets of production can be compared to the actual costs. This information can then be used to improve the new quote. Granted, this can be done with a good paper control system if it is managed well. However, most paper systems store data for different production functions in different locations or offices, which means that the user must be persistent in seeking out the existing data required to compare any new quote. Having an easily accessed computerized database can place this information at the fingertips of estimators who will then be more likely to take advantage of the existing data.

### *3.3.2 Scheduling*

Most MPC system software packages provide some scheduling techniques where jobs can be scheduled using a variety of options. Typically both finite and infinite scheduling is available but on some systems only infinite scheduling can be performed. The advantages to using one of these two methods allows a user to manipulate many different schedule options and quickly see the results. For example, a system that provided infinite scheduling methods would typically allow both forward and backward scheduling where a user could quickly input the required start date or promised ship date and then view data of the required capacity on each of the affected work centers. This graphical and numerical data can be calculated and displayed by month, week, day, and hour for individual work centers on many systems.

On systems that provide finite scheduling methods, where scheduling can only be done to 100% of capacity, scheduling can be based on priority codes, ship dates, priority start dates and remaining hours, to maximize the efficiency of the shop. One software system reviewed provided a "what if" option that allowed a user to quickly review many different scheduling options and make changes to optimize production. Generating equivalent scheduling options manually would be very time consuming and prone to error.

### *3.3.3 Capacity*

By reviewing the schedule of critical work centers, more effective estimating can also be accomplished. If a new quote is being prepared and the resulting work load from this new quote requires overtime, added costs for this overtime can be included in the quote. A quick review of current and future capacity based on the scheduled workload at specific work centers will reveal this critical over capacity situation. The "what if" scheduling options could also be used to rework the schedule to find ways to reduce the need for overtime. The capacity data can be used to schedule maintenance at times that will create the least interruption to production. Access to past work center utilization data can help plan for the future. Historic information on setup times, run times, and maintenance can all be provided by most control systems. This data can be very valuable for future capacity planning.

### *3.3.4 Shop Router/Process Planning*

One of the major advantages to using a computerized control system is in the use of computer-aided process planning. Process planning can be very time consuming and often requires the duplication of methods that are used to produce many similar parts. The ability to access previous shop routers and use the existing process planning for new jobs by simply copying the data or by modifying the data, can save time. This can be done by using group technology part identification methods or by using standardized filing methods where similar parts can be easily identified. The filing method used should make it easy to conduct a database search to find all parts previously processed that are similar to the part currently being quoted or planned. For example, a typical task for a machine shop might be to produce a variety of shafts. Each shaft might be a different length and diameter, but the processing steps necessary to produce these shafts might be identical. All shafts will start their processing by being routed through the materials shop, to the saw shop, to the CNC turning area and then to deburr and finally to inspection. Each of the sequenced operations identifies specific work centers and production methods that are often identical. By using existing shop router information from the database, the planning workload can be significantly reduced in conjunction with improved plans and greater consistency.

### *3.3.5 Material Costing*

Most control packages will include a materials package that will quickly calculate the materials cost for batches of parts, although this is not typically a complex calculation and can easily be done by hand. The advantage of the computer, and its ability to calculate many options quickly, will often allow better analysis of materials utilization methods and cost considerations. Once the cost information for a specific part is input to the system, many "what if" options such as discount purchases for variable purchase amounts, cutting charges, shipping charges, scrap rates, and material burdens can quickly be reviewed for the most cost effective option. These material costs can also be filed for review when new material quotes are needed.

### *3.3.6 Data Collection*

The success of any MPC system is ultimately determined by the quality of the data that the system provides. If the data is collected weekly, by the use of time cards, it will not be possible to effectively control production that requires less than one week to complete. Another computer option is to use some form of bar code data entry system to collect the necessary production data. A simple calculation, based on S & R's requirements, indicated a payback period of one year when costs of manually entering the data and using four bar code systems were compared. In addition, the use of a bar code data entry system would also allow real-time data access that would provide improved control in most instances. The timely entry of production data is what allows most shop floor systems to be effectively used for day to day evaluation and control. The advantages to entering the data using the bar code systems, accuracy and real-time data feedback for example, more than warrants the investment. See investment costs on page 65-66 for more detail.

#### *3.3.7 Inventory Control*

Most systems provide comprehensive inventory control that allows a user to control raw material, finished goods and purchased parts. A real-time balance of raw material and finished parts is maintained and can be accessed at any network station. Costs of material or parts can be maintained by standard, average or last cost options. Parts that are used frequently can be identified so that the system automatically prompts when stocks are low and need to be reordered. Parts or material that are in stock can be assigned to specific jobs indicating that they are in stock but assigned to a job. An annual usage report indicating the use of specified material or parts each month can be accessed.

### 3.4 Software Review

Once it was determined that a computer system would best achieve the objectives of the company, existing MPC system software was reviewed. This was done using sales information provided by software companies, by interviewing current users of software, (see Appendix C) and through on-line demonstrations of software (see Appendix D). In support of computerization, a recommended part numbering system that could easily allow S & R to input the currently produced parts into a computerized MPC system was suggested.

The next step was to formulate the architecture of the MPC system and plan for the computer system, both hardware and the type of software, that would be necessary to achieve control using this MPC system. This involved determining the quantity, system requirements and location in the plant of any computer equipment.

## 3.5 Implementation Plan

Finally, an implementation plan was developed (see Figure 5) that would allow S & R to maintain production and follow a systematic plan. The implementation plan provides guidelines for collecting all the necessary data to be input into the system so that the MPC system could be brought online in an efficient manner. This included choosing and purchasing computer systems, preparing system data, preparing inventory data, hardware and software system setup and input of inventory data.

To prepare for effective implementation, several forms were developed that allowed S & R to gather information on activities that would eventually need to be tabulated and input to the computer system. A shop router (see Figure 6) was created that could be used to define the process planning, using a paper system, and simulate the computer generated data that would eventually be part of the system.

Based on the structure and data collection methods of most computerized control software packages, work centers also needed to be defined and their capacity calculated. A temporary paper system that would allow S & R to start gathering this important data and give the shop floor personnel an idea of what they might expect when the computerized system was eventually brought online was suggested. Standard forms and methods for collecting setup-times and run-times (see Figure 7) for each work center were also provided.

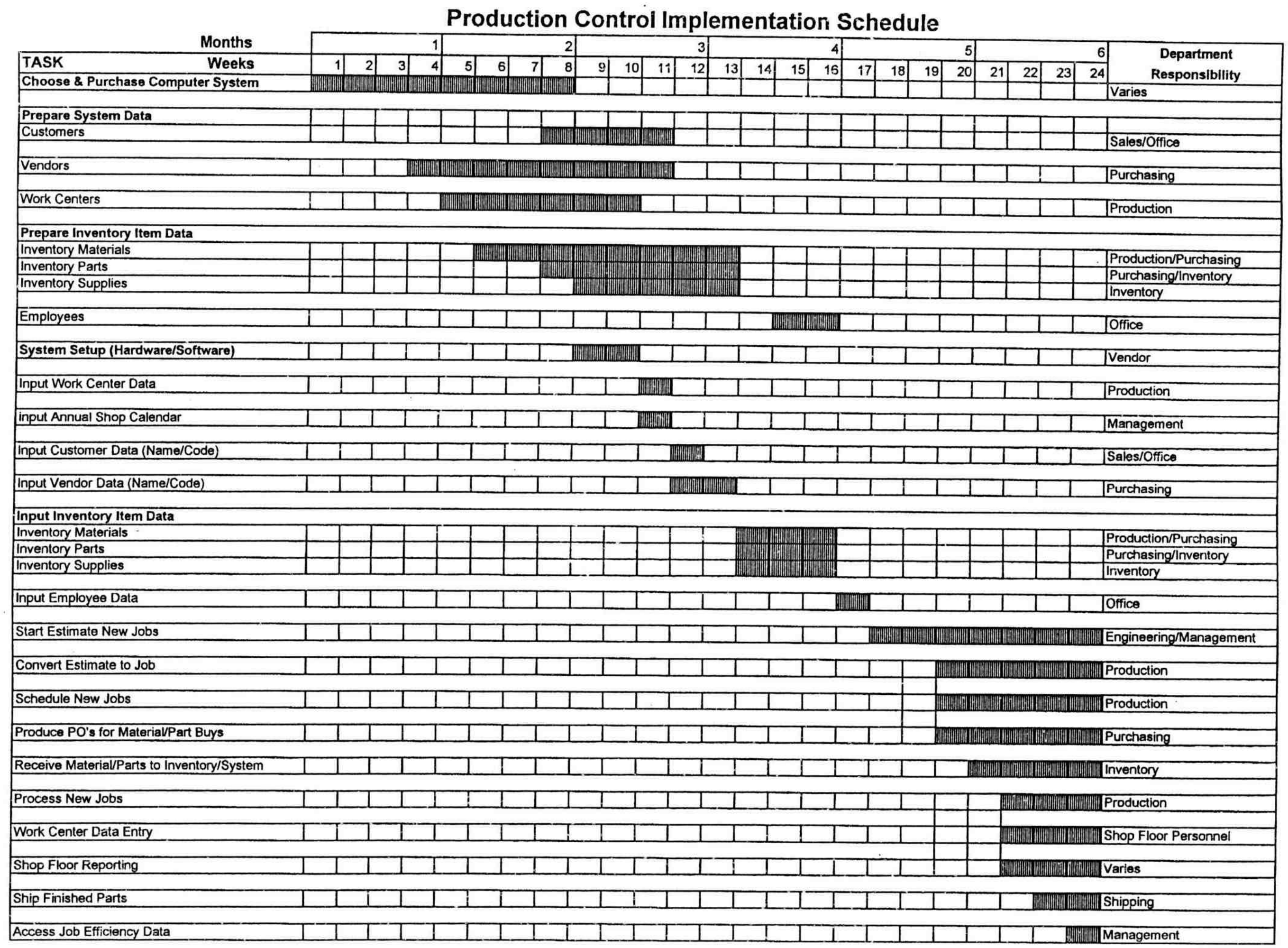


Figure 5. Implementation Schedule

**SHOP ROUTER**

| | | |
|---|---|---|
| PO # : | Prepared By: | Sheet of |
| Job # : | Date: | |
| Part # : | Material Type: | |
| Drawing # : | Material Description: | |
| Part Description: | Revision # : | |
| Order Qty: | Customer # : | |
| Make Qty: | Customer Address: | |

| Work Center | Op # | Operation Description | Setuptime | Runtime | Tooling | Misc | Location |
|---|---|---|---|---|---|---|---|
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Figure 6. Sample Shop Router.

**Sample Form**

**Setup/Run Time Data Form**

Please use this form to gather preliminary data on setup/run time for each work center. Setup is defined as [17] 1.) "The work required to change a specific machine, resource, work center, or line from making the last good piece of unit A to the first good piece of unit B. 2.) The refitting of equipment to neutralize the effects of the last lot produced and preparation of the equipment for production of the next scheduled item."
Run Time is defined as the total time necessary to process (cut, weld, paint etc.) a job or part. That includes loading a part to a fixture, processing the part, and unloading the part.

**Work Center Name** ________________________________

**Job #** ______________________ **Date** ____________

**Part # (If available)** ______________________

**Short description of setup:** ______________________________

________________________________________________

**Setup Time Data:**

**Start Time** ________________ **End Time** ________________

**Short description of process:** ______________________________

________________________________________________

**Run Time Data:**

**Start Time** ________________ **End Time** ________________

**Number of Parts Processed** ________

Figure 7. Setup/Run-time data collection form

## 3.6 Measuring Productivity Improvements

The implementation of this formal MPC system should not only provide for improved system control, it should also lead to improved productivity. To measure any change in productivity, a base value using the current production system, must be determined. Then, at a later date when the new MPC system is being fully utilized, new data can be gathered and comparisons made. A review of the following areas is suggested:

### *3.6.1 On-time Shipping*

A measure of the percentage of jobs that are currently shipped on schedule. This data should include the estimated hours and the actual hours required for completion of the job. If the job is not shipped on schedule, some reference to the number of days that the job is late should be made and documentation describing the reason for the lateness should be noted.

### *3.6.2 Delivery Costs*

Determine the percentage of the parts or materials that are currently shipped using overnight delivery costs that could be shipped by less expensive means.

### *3.6.3 Unplanned Overtime*

Determine the number of unplanned overtime hours worked as a percentage of the total hours necessary for completion of the job.

### *3.6.4 Rework*

Determine the number of hours of rework performed as a percentage of the total hours worked to complete the job.

The collection and evaluation of this data will allow future changes in productivity to be measured, which should provide an effective method to determine how well the new MPC system is performing.

## 3.7 Employee Educational Requirements

Finally, a proposed educational plan was outlined that would help S & R identify the types of employee training they would need to assure effective implementation and efficient use of the software. These educational recommendations included a set of course objectives for a class that could be offered at a local community college or similar institution. The objectives are outlined and listed here:

This course (Suggested Title "Introduction to Manufacturing Methods and Control") should provide the shop floor employees with an overview of the following manufacturing functions so that after taking this introductory course they should be able to:

Define the following manufacturing functions associated with a job shop, including:

- Plant Capacity, Work Center capacity, Scheduling, forward and backward scheduling, finite and infinite scheduling, Setup-time, Run-time.

Understand the importance and definition of the following terms:

- Productivity, Efficiency, Material Handling, Value Adding Process, Tooling Costs, Direct and Indirect labor costs, overhead, burden.

Be familiar with the following Inventory terms:

- Inventory, Inventory Control, Inventory Costs, Stock Unit, Usage Unit, Purchase Unit, Lead-time, Economic Order Quantity, Shop Materials.

Understand the importance of controlling the following functions:

- Man Hours, Job Tracking, Real-Time Data, Process Planning, Shop Router, Expediting, Lead-time, Work in Process (WIP), Bill of Material (BOM).

Define and understand the following Quality terms:

- Quality, Quality Control, Inspection, and the costs associated with these terms.

# 4. Objectives and Scope

After completing the case study at S & R , it was suggested that other job shops might be in a similar position and could also benefit from the process presented to S & R Industries. A closer look at job shops in general provided information to continue this project. Currently there are over 36,000 [18] job shops in the U.S. Over 4,000 of these job shops employ between 20 and 49 employees and generate annual sales of over $14 billion. A survey was sent to all job shop companies listed in the American Business Disk that employed between 20 and 49 employees and were located in Washington or Oregon. Results from this survey indicated that: the average annual sales for these companies was $3.6 million, and that they employed an average of 38 employees of which 76% were shop floor employees and 10% were shop floor managers. There were 132 companies total and the response was ten percent.

The survey looked at two major topic areas, (1) related to the shop floor control (SFC) and the use of computerized verses paper systems, and (2) related to the education and training that shop floor employees had received in these areas. The questions on SFC asked the respondents to indicate if they used a computer or a paper system for control. The results indicate that computers were used by the majority of respondents; 66% used computers for scheduling, 58% for capacity planning, 78% for inventory control, 69% for raw materials control, 69% used a shop router/traveler, 55% used MRP and 40% used MPS. The questions on education asked employers to identify their training source for each area listed above. The overall response indicted that 10.6% received their training from a college course, 8.6% from vendor training, and 80.8% received no formal training. The complete survey results can be found on pages 8-10.

With the information gathered from the case study at S & R Industries and the data from the survey of job shops, the objectives and scope for this thesis were defined as follows:

1. Create an implementation plan for a computerized manufacturing planning control system that can be used in job shop companies that employ between 20 and 49 people.
2. Provide a mechanism to assess the need for a computerized manufacturing planning and control system in a small company. A standardized form that can be used as a check sheet to determine if there is a need for implementing a formalized computer control system was created. This form will aid a company in assessing what problems are currently present and which of those problems might be addressed with the use of a computerized control system.
3. Describe the benefits of implementing an MPC system, including an outline of where the benefits should be found when the new system is implemented. Provide a mechanism for prioritizing business releases based on results from an internal assessment in the following areas:

    - Job Quoting
    - Capacity Planning
    - Scheduling
    - Shop floor Control
    - Material Estimating
    - Inventory Control
    - Reporting and Costing Analysis

4. Suggest a method for assigning work that will allow for efficient capacity planning, scheduling and control of shop activities. Provide forms for use in gathering the data

necessary for implementing and using the control system, including forms for gathering setup and runtime standards for each work center.

5. Provide a method that will allow the applicability of currently available software to be evaluated and ranked based on the defined company production control objectives.
6. Identify the requirements necessary in choosing and assigning a champion or project leader to implement the new computerized system. This leader will coordinate the implementation efforts of all staff and personnel that will be involved with set up of the new computerized control system so that a smooth transition can be achieved.
7. Outline the format for a Gantt Chart that will define the tasks necessary with suggested time frames for the successful implementation of the new system.
8. Define the educational requirements for shop floor employees that are necessary for the successful implementation of the production control system, including estimated costs for this continuing education.
9. Outline the costs for hardware, software, and any associated costs that might be incurred with the implementation of a computerized production control system.
10. Review methods for measuring the productivity improvements that should result after the successful implementation of a computerized production control system.
11. Create a pull-out section that can stand alone as an implementation document.

# Implementing A Computerized Manufacturing Planning and Control System In a Job Shop Environment

## This Chapter is Designed as a Pullout Section

# 5. Implementing A Computerized Manufacturing Planning and Control System In a Job Shop Environment

Implementing a computerized Manufacturing Planning and Control (MPC) system can be a time consuming and costly undertaking. This document will help determine the benefits of such a system and provide a step-by-step implementation plan. The proposed ten step plan will allow a user to achieve improved control with a minimum decline in productivity. Sample charts and forms are provided, that were developed and used during a case study performed at a typical job shop. These forms will aid in the planning of the new system and also allow users to gain an in-depth understanding of the data that must be prepared before a computerized system can be effectively implemented. The benefits that are available from using an effective computerized MPC system are first described and a summary of the ten steps is provided.

## 5.1 Summary of Benefits

There are many variables that need to be reviewed before an effective MPC system can be implemented. The system that is chosen has to be cost effective, it needs to provide user friendly software for employees, provide the right database for effective shop floor control, and include adequate training for employees to become effective with the software. However, the benefits that are available following a successful implementation can be great and are summarized here. These benefits are described in more detail at the end of this document.

### *5.1.1 Quoting*

Computerized systems allow access to data by referencing part type, part name, vender name, part number, and production date to identify the similarities between parts. Systems can provide information on what materials were used, where the materials were purchased, the cost of materials and many other relevant costs. Important data on problems that might have occurred during production, can also be reviewed so that the same mistakes are not repeated.

### *5.1.2 Scheduling*

Using one of many different scheduling options and being able to quickly see the results provides many advantages. For example, a system that provides infinite scheduling options would typically allow both forward and backward scheduling, where a user could quickly input the required start or promised ship dates and then view graphical data of the required capacity on each of the affected work centers. Some systems provide a "what if" option that allowed a user to quickly review many different order promising and scheduling options and make changes to optimize the production schedule.

### *5.1.3 Capacity*

If a new quote is being prepared and the resulting work load from this new quote requires overtime, added costs for this overtime can be included in the quote. A quick review of current and future capacity based on the scheduled workload at specific work centers will reveal this critical over capacity situation.

### *5.1.4 Shop Router/Process Planning*

The ability to access previous shop routers and use the existing process planning data to create new plans by simply copying the data or by modifying the data, can save time. Many jobs have similar sequenced operations and identify specific work centers and production methods. By using existing shop router information from the database the planning work load can be reduced.

### *5.1.5 Material Costing*

Once the material cost information for a specific part is input to the system, many "what if" options such as discount purchases for variable purchase amounts, cutting charges, shipping charges, scrap rates, and material burdens can quickly be reviewed for the most cost effective option.

### *5.1.6 Data Collection*

The use of a bar code data entry system allows real-time data access that can provide improved control in most instances. The timely entry of production data is what allows most shop floor systems to be effectively used for day to day evaluation and control.

### *5.1.7 Inventory Control*

A real-time balance of raw material and finished parts is maintained and can be accessed at any network station. Costs of material or parts can be maintained by standard, average or last cost options. Parts that are used frequently can be identified so that the system automatically prompts when stocks are low and need to be reordered.

## 5.2 Summary of Ten Step Process

The first step "Determine if an MPC system will benefit your company" is accomplished by answering a set of questions that will allow a company to quantify these benefits. It provides an estimate of the possible benefits as a percentage, the higher the percent the greater the estimated benefit. Step two involves identifying a project leader who will champion the implementation process, someone who understands the current system and the objectives of the new control plan. The next step is to document the current system so that problems and inaccuracies can be identified. From these problems a set of control objectives are identified and software and hardware systems chosen. Educational training needs are determined and an implementation time-line is developed. This includes hardware setup, data collection, data input and conducting the full implementation. The final step is to measure the new control system's performance.

The ten implementation steps are listed below:

- Determine if an MPC system will benefit your company
- Identify a project leader
- Document the current production system
- List problems with the current system
- Define MPC system objectives
- Choose MPC system hardware and software
- Assess the educational and training needs of employees
- Determine implementation costs
- Develop an implementation timeline
    - a. Hardware selection and data preparation
    - b. Data input
    - c. Conduct full implementation
- Measure project performance

## 5.3 Determine if an MPC System will Benefit Your Company

Deciding whether an MPC computerized system will benefit a company is a complex decision. To simplify this task, a set of questions that will help quantify whether a computerized system will be beneficial have been developed. This set of questions needs to be rated from one (1) to five (5) based on the estimated savings that might be realized if each were implemented and fully effective. The results will indicate, quantitatively, the benefit a company should realize by implementing a computerized production control system.

By rating the improvement to your system, you can estimate the overall benefit and the benefit of each business area. Rate each question from one (1) to five (5), with a rate of five indicating the greatest gain. Any question (actually the topic of the question is what is being evaluated) that you estimate would provide a substantial savings by being 100% effective, if implemented, should be rated a five (5). Any question that you feel would provide no benefit should be rated a one (1). For example, question one asks,

*Rate the improvement to your system that you might gain if you could efficiently review previous quotes so that they could be easily modified and used for new quotes.*

*Rate: 1____2____3____4____5____*

If your company is not currently doing this, but implementing a system to do this would lead to substantial financial savings, you would rate this question either four or five. (more substantial savings would be rated five). On the other hand, if your company is currently doing this effectively and there would be "no" savings by implementing such a system, you would rate this a one (1). If your company is currently doing this, but not effectively, (which means there is room for improvement) then you could rate this somewhere between one (1) and five (5) based on your estimate of those savings. Any question that is not appropriate can be omitted. You can also add questions, but it is important that you follow the current question format.

The questions are listed based on related business areas and can be used to estimate the overall benefit or the benefit related to each business area. Currently the questions can be grouped into the following business areas:

- ***Job Quoting*** Questions 1-4
- ***Scheduling*** Questions 5-7
- ***Shop Router*** Questions 8-10
- ***Materials Estimating*** Questions 11-12
- ***Shop Floor Control*** Questions 13-15
- ***Inventory*** Questions 16-17

By evaluating the questions in groups, based on business topics, it should be possible to determine which areas will provide the greatest savings. If there is evidence that savings in specific areas[1] could be realized, you will need to estimate if these savings can warrant an investment in a computerized system. It is believed that a properly implemented and operated computerized system should provide some benefit to any company. How much benefit must be determined by your company's individual set up. The following method will help estimate need and benefit.

---

[1]Many software packages are sold as business units and it is possible to purchase those units that are most required or beneficial.

### *5.3.1 Job Quoting*

1. Rate the improvement to your system that you might gain if you could efficiently review previous quotes so that they could be easily modified and used for new quotes.

   Rate: 1____2____3____4____5____

2. Rate the improvement to your system that you might gain, if, when preparing a new quote, it was easy to find related information such as material and part costs, vendor names and lead times about existing quotes.

   Rate: 1____2____3____4____5____

3. Rate the improvement to your system that you might gain, if, when quoting new jobs, you could modify a quote from a previously produced quote and save 50% of the effort.

   Rate: 1____2____3____4____5____

4. Rate the improvement to your system that you might gain, if, while preparing quotes, you could consider work center capacity and relate the capacity to the possibility of overtime.

   Rate: 1____2____3____4____5____

### *5.3.2 Scheduling*

5. Rate the improvement to your system that you might gain if you could review the capacity of critical work centers and use that capacity data when preparing quotes.

   Rate: 1____2____3____4____5____

6. Rate the improvement to your system that you might gain if you could frequently review the schedule with the intent of improving the schedule (a "what if" review)? This does not include modifying the schedule because of problems.

   Rate: 1____2____3____4____5____

7. Rate the improvement to your system that you might gain if it was easy for you to make changes to your production schedule as new jobs are added.

   Rate: 1____2____3____4____5____

### *5.3.3 Shop Router*

8. Rate the improvement to your system that you might gain if you used a shop router (paperwork) to outline procedures for each work center.

   Rate: 1____2____3____4____5____

9. Rate the improvement to your system that you might gain if a more explicit shop router that defines production problems in more detail and includes previous setup data was used.

   Rate: 1____2____3____4____5____

10. Rate the improvement to your system that you might gain if you could create a shop router from the previously existing shop router of a similar part (i.e. Variant Computer-aided Process Planning).

    Rate: 1____2____3____4____5____

### *5.3.4 Materials Estimating*

11. Rate the improvement to your system that you might gain if you could efficiently make numerous materials calculations to optimize you materials cost rather than make one simple material calculation.

    Rate: 1____2____3____4____5____

12. Rate the improvement to your system that you might gain if you could include options such as: cutting charges, shipping charges, scrap rates, material burdens and discount purchases when making material calculations.

    Rate: 1____2____3____4____5____

### *5.3.5 Shop Floor Control*

13. Rate the improvement to your system that you might gain if you could review the production status of a part on the shop floor in real-time (dynamic production status reporting).

    Rate: 1____2____3____4____5____

14. Rate the improvement to your system that you might gain if you could review the production status of jobs that require short processing time through the shop.

    Rate: 1____2____3____4____5____

15. Rate the improvement to your system that you might gain if you could verify the status of any job on the shop floor without leaving your desk. (provide instant feedback to customers)

    Rate: 1____2____3____4____5____

### *5.3.6 Inventory Control*

16. Rate the improvement to your system that you might gain if you could verify, from your desktop, what material and parts are currently in inventory. (real-time material and parts inventory)

    Rate: 1____2____3____4____5____

17. Rate the improvement to your system that you might gain if you could efficiently calculate material and parts usage rates for specified time frames. (inventory turnover)

    Rate: 1____2____3____4____5____

*5.3.7 Calculating the Estimated Benefit*

After you have rated and answered the questions, you must then perform this simple calculation.

**B = (R/Q)100**

**B = Estimated Benefit (percentage)**

**R = Sum of the rates for questions answered**

**Q = Total number of questions answered multiplied by 5**

The estimated benefit "B" is given as a percentage. The greater the percentage the greater the benefit. The example on the next page should help.

Each of the following seven questions were reviewed and rated one (1) through five (5) based on the estimated saving that might be realized if implemented.

1. Rate the improvement to your system that you might gain if you could efficiently review previous quotes so that they could be easily modified and used for new quotes.

   Rate: 1____2____3____4____5__√__

2. Rate the improvement to your system that you might gain, if, when preparing a new quote, is was easy to find related information such as material and part costs, vendor names and lead times about existing quotes.

   Rate: 1____2____3____4__√__5____

3. Rate the improvement to your system that you might gain, if, when quoting new jobs, you could modify a quote from a previously produced quote and save 50% of the effort.

   Rate: 1____2____3__√__4____5____

4. Rate the improvement to your system that you might gain, if, while preparing quotes, you could consider work center capacity and relate the capacity to the possibility of overtime.

   Rate: 1____2____3____4__√__5____

5. Rate the improvement to your system that you might gain if you could review the capacity of critical work centers and use that capacity data when preparing quotes.

   Rate: 1____2____3__√__4____5____

6. Rate the improvement to your system that you might gain if you could frequently review the schedule with the intent of improving the schedule (a "what if" review)? This does not include modifying the schedule because of problems.

   Rate: 1____2____3__√__4____5____

7. Rate the improvement to your system that you might gain if it was easy for you to make changes to your production schedule as new jobs are added.

   Rate: 1____2____3__√__4____5____

**Solution**

**B = (R/Q)100** **R = (5+4+3+4+3+3+3) = 25**

**B = ((5+4+3+4+3+3+3)/7(5))100** **Q = 7(5) = 35**

**B = (25/35)100**

**B = 71%**

This indicates that a substantial benefit should be achieved if a computerized system is implemented. The closer the result to 100%, the greater the predicted benefit. Using all seventeen questions the result gives an "overall" estimate based on the combined results of a typical MPC system. The formula can also be used to predict the benefit for specific business areas. Further review of these individual business areas might indicate that substantial saving could be achieved in one or two areas but not the entire system. A review of the Job Quoting business area indicates:

**B = (R/Q)100 R = (5+4+3+4) = 16**

**B = ((5+4+3+4)/4(5))100 Q = 4(5) = 20**

**B = (16/20)100**

**B = 80%**

A substantial savings is indicated in the job quoting business area. However, when compared with the savings shown below in the Scheduling business area there is a considerable difference.

**B = (R/Q)100 R = (3+3+3) = 9**

**B = ((9)/3(5))100 Q = 3(5) = 15**

**B = (9/15)100**

**B = 60%**

Most software packages reviewed during the S & R case study provided for an initial investment and subsequent business area add-ons. Area benefit weightings can be used to prioritize or justify area add-on implementations.

## 5.4 Identifying A Project Leader

The success of most new projects depends to a great extent on the quality and skills of the person identified as the project leader (champion) and on their abilities to direct the project and motivate others to contribute. Implementing an MPC system requires coordinating people from a number of different departments and collecting data to be used by the system. It will also be the responsibility of the project leader to review the hardware and software that best fits the company needs. They will need to develop a specific implementation plan that describes what needs to be accomplished, when it needs to be done, and who is responsible for each step of the plan.

The project leader will be responsible for the overall implementation of the system. This individual needs to be somebody in whom other employees have confidence, someone whom other employees respect and with whom they will cooperate. The project leader must have a good understanding of the company and how it currently functions. They must be able to direct others towards the overall company and project goal and must also be personally committed to the successful implementation of the MPC system.

## 5.5 Document the Current Production System

Before any planning for the proposed new system is undertaken it is important that the current production system be reviewed and documented. This can be achieved by creating a flow chart of the current system. Viewing this flow chart allows each function of the current process to be graphically related to the other functions within the plant. It clearly shows how each of the activities such as sales, purchasing, inventory, and production are related and how information and material flows from one area to another.

This chart can be created by simply listing the departments in a row across the top of the chart (a section of a sample chart is shown in Figure 8 on the next page) Sales, Office, Engineering, Production, etc., by creating columns for each department, and then adding the functions under each department. Each department is then connected to describe the flow of information by directional arrows. Using this flow chart, it is easy to identify problems in the system. The chart is later modified to define improvements to the system. It is highly recommend that a similar flow chart be used because:

- It is easy to see what is being done and who is doing it.
- The relationship between departments is evident.
- The flow of information and data can be identified.
- Problems with the system can be more easily identified.
- Changes can be more easily made to standardize the system.

Once this chart is created, it will provide the implementation team with a graphical description of the relationship between departments. It helps identify the route or sequence of events that a job follows through the system and provides insight into discrepancies and problems in the system. By reviewing the whole system graphically a standardized system is easily developed. As a project leader who understands the current system, one might be tempted to skip this step. However, using the flow chart provides everybody involved with an opportunity for input and a chance to identify problems and to suggest improvements to the current system. Skipping this step is not recommended.

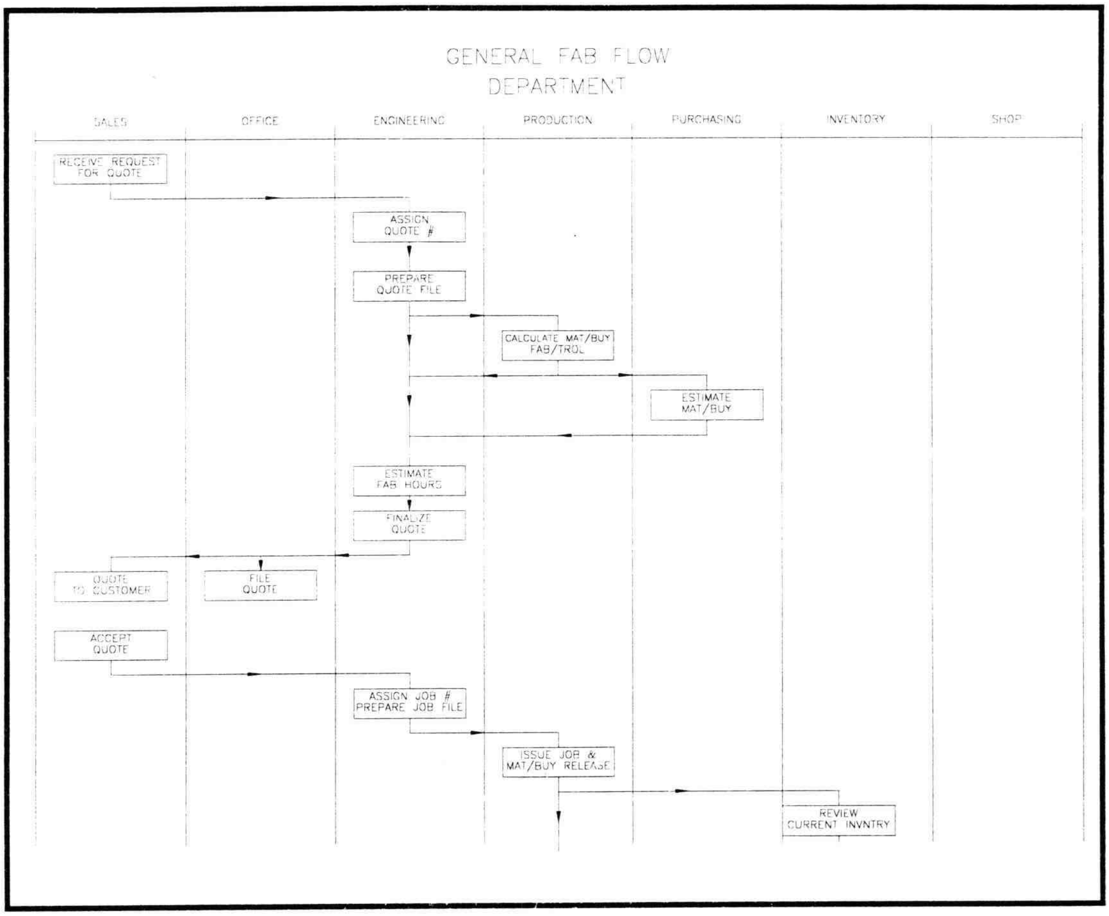


Figure 8. Section of S & R case study original flow chart

## 5.6 List Current Problems

Once there is agreement on how the current system functions, it is not difficult to identify areas in the system that can be improved. Brainstorming while reviewing the flow chart that graphically describes the system can lead to the identification of problems and to the development of a set of management objectives. The objective list is then used to choose the optimum MPC system software. The identified problem list is basically a listing of ideas determined by the personnel from sales, production, purchasing, etc., defining how each individual could perform a more effective job if they could get specific information, or if they had access to specific data. Each identified problem is then reviewed and an applicable objective that would correct the problem is written. Examples of identified problems are listed below:

- Current quotes are inconsistent in format and content. There is no current standard format for making quotes which results in inconsistencies which does not always provide production with the data necessary to effectively process a job.
- There is no method of tracking work center capacity. Quotes are often made without work center capacity consideration which leads to over capacity situations that often require overtime. Quoting jobs at standard rates when work centers are over capacity leads to overtime, which in turn reduces profit.
- It is difficult to access previous quote data for review when quoting similar jobs. The current filing method, for filing quotes, does not allow easy access to previous quotes based on request similarity. This often results in a new quote being made rather than an old quote being modified. In addition, problems encountered with a previous job can be repeated if the problems are not identified when similar jobs are quoted.
- The lack of use of a detailed shop router, to adequately define the production process, results in engineering spending 20 to 30 % of their time in the shop solving production problems. These problems typically require decisions to be made on how a part or job should be processed through the shop.
- The current method used for tracking jobs is only updated once per week which does not allow for effective control of jobs that are completed in less than this time frame.
- There is currently no efficient method used to determine existing material inventory. Material in inventory is determined by physical inspection and is used on a first come basis. This often results in material shortages.
- It is currently difficult to determine when to pay purchase orders (PO's) as there is no efficient method to determine when a PO is complete. Receiving will often accept

partial PO's. It later becomes difficult to determine which PO's are complete and need to be paid. There is no efficient method of tracking outstanding PO's.

- There is no current method of tracking lead-times for purchased items. This leads to parts being shipped by more expensive methods than is necessary. Often a part will be ordered and requested to arrive over-night air freight. If the order lead-time for delivery of this part had been known, it could have been ordered earlier and shipped by less expensive methods.
- It is currently difficult for Purchasing to realize quantity discounts when purchasing parts as there is no effective way to review the upcoming job schedule or part history information when ordering parts.
- Planning shipping dates in advance can be very difficult when the schedule is frequently changed. Therefore it is difficult for Purchasing to realize both receiving and shipping transportation discounts. Typically, a truck is ordered when a job is complete. Combined shipments are rarely considered.

## 5.7 Define MPC System Objectives

The defined problems are then reviewed and used to create a set of objectives that can be implemented. The resulting outcomes should then correct the problems. Examples of Identified objectives are listed below:

- Make efficient, accurate quotes based on capacity of the plant in general, but more importantly based on the capacity of each work center.
- Efficiently access previous quotes so that these quotes can be reviewed and possibly modified for future use. This would allow problem jobs to be reviewed so that similar mistakes would not be made.

- Efficiently calculate material requirements for new jobs/parts and store this data for future use on repeat jobs/parts bill of material.
- Accurately track all material and parts in inventory and their location in the plant.
- Determine and track the ordering history for EOQ's and the lead-times of buyout parts so that Purchasing can order these parts when needed.
- Access previously purchased material and purchased part costs for source reference.
- Efficiently schedule jobs through the shop based on work center capacity, job priority and available labor man-hours.
- Produce an effective shop router (process plan) outlining production requirements so that parts/jobs will flow through the shop more efficiently.
- Prepare accurate shipping documentation in a timely manner.
- Determine what parts/material PO items have been received so that complete PO's can be paid.
- Determine EOQ's based on the planned schedule of upcoming jobs so that price breaks can be realized.
- Access the current status of any job in the plant.
- Review the record of actual times and costs for each job to determine efficiency.

Using this management objective list, a new production control system is outlined.

This system is developed so that it will address current problems and meet the defined management objectives. A new flow chart is then produced that describes this proposed new system. See figure 9.

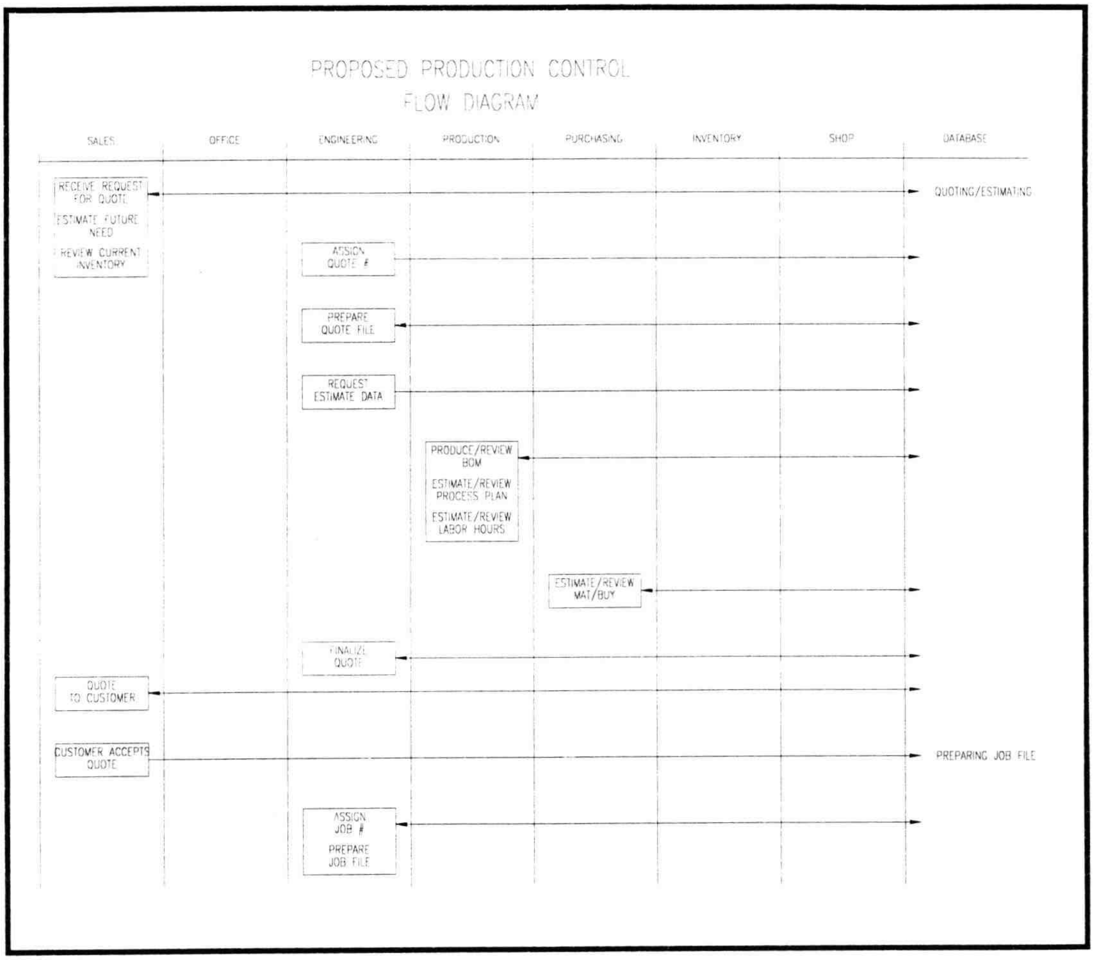


Figure 9. Section of proposed S & R flow chart

Two characteristics are needed to correct typical problems. One is to create a formal, encompassing system to allow for manufacturing control. This formal system should support quoting of new jobs, material management, inventory control, capacity planning and scheduling, and most importantly, should provide feedback on the production activities. The second is to design a standard computer implementation to facilitate this formal structure. A computerized "real-time" software system should drastically improve tracking and transaction processing. Real-time computerized data access allows retrieval of quote history, which provides management with critical cost data to make new quotes, and when appropriate to modify existing quotes. Each of the functions outlined in the proposed new control system should be linked together by a computer database. The use of a computerized control system allows efficient tracking and management of large numbers of material types and parts. It also provides for real-time data access. To determine which software package will best achieve this, a method for identifying and evaluating software is described.

## 5.8 Choosing MPC System Hardware and Software

In order to identify the most cost effective MPC system software, a criteria list is developed to evaluate each software package. This criteria list is developed from the previously identified set of management objectives. The intent is to compare each software package against the criteria and to rank them quantitatively. Once this is done, on-line demonstrations of the software can be performed. Sample software evaluation criteria are listed below:

- Make efficient, accurate quotes based on capacity of the plant and work centers.
- Efficiently calculate material requirements for new jobs/parts and store this data for future use on repeat jobs/parts.
- Determine what material is in inventory and its location in the plant.
- Efficiently schedule jobs through the shop based on work center capacity, job priority, and available labor man-hours.
- Produce a process plan/router so that parts/jobs will flow through the shop more efficiently.
- Prepare accurate shipping documentation in a timely manner.

- Determine what buyout/material PO items have been received so that complete PO's can be paid.
- Access the current status of any job in the plant.
- Review the record of actual times and costs for each job to determine efficiency.
- The initial investment for the software and hardware should be within budget, and if possible provide for a small initial investment with add-on modules.
- Accounting, payroll, and data collection modules should be available for future use.
- User-friendly sales documentation with carefully defined capabilities.

When the criteria are developed, each item on the criteria list is then weighted from zero to ten, a score of ten indicating that the criteria is most valuable and a score close to zero defining less significance. The weights can be obtained by averaging evaluations provided by persons from each of the following areas; inventory control, manufacturing engineering, production control and shop management. Each should evaluate the criteria, based on the importance of each criteria, when viewed from their department point of view.

Once this is done, the sales documentation provided with each software package is reviewed and rated against the criteria (this should be done by the project leader). If a software package completely meets the stated criteria, it is given a rating of ten, if it does not meet the criteria, it is rated zero. The ratings for each criteria are then multiplied by the evaluation weights to find the totals. The software is then ranked best to worst. An example is shown in Figure 10.

| Production Control Software Review | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | |
| | | | CRITERIA 1-12 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| CRITERIA | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | |
| RANK VALUE * | | 7 | 7.3 | 7.3 | 10 | 9.8 | 6.5 | 6.5 | 9.3 | 9 | 7.8 | 6.3 | 7 | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | Rank |
| SOFTWARE | | | | | | | | | | | | | | Total | Order |
| 1 | FAB/TROL | 0 | 7 | 10 | 0 | 2 | 10 | 2 | 0 | 0 | 4 | 0 | 6 | 252 | 4 |
| 2 | JOBBOSS | 10 | 6 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 8 | 10 | 10 | 821 | 1 |
| 3 | REALTRAC | 7 | 6 | 7 | 10 | 10 | 0 | 0 | 10 | 10 | 4 | 0 | 4 | 554 | 3 |
| 4 | SCS | 10 | 7 | 10 | 10 | 8 | 10 | 10 | 8 | 10 | 2 | 10 | 8 | 743 | 2 |
| | | | | | | | | | | | | | | | |

* Each criteria was ranked 1-10 with 10 being the most valuable.
Each of the software packages was then rated on a scale from 1 to 10.
A score of 10 indicates that the software meets the criteria very well
compared to a score of 0 which indicates that the software does not meet the criteria.
These scores were then multiplied by the rank values and summed to find the
rank order.

Figure 10. Sample software evaluation data

It should be noted, that when reviewing software documentation, it is often difficult to determine how well a software package will perform a specific function. This is due to the completeness or incompleteness of the sales information provided by each company. If this occurs, make sure that these discrepancies are noted and addressed when the on-line demonstration is done. This can also be addressed when you call current software users. Examples of questions that might be asked when calling a current user are listed below. Most software sales people will provide you with a list of local users. Sample Software Current user Questions are listed below:

- *How long have you used XXXXX software?*
- *What modules do you use?*
- *What was the total cost for these modules?*

- *Which of the following functions do you currently use with XXXXX software? Process Planning, Estimating, Inventory Control, Tracking, Time keeping, Shipping, Accounting functions, Scheduling, Purchasing.*
- *How many people access XXXXX software?*
- *Is the software used on a network and if so what network?*
- *How easy was the software to install and use initially; was it easy to change from the paper method you were using to XXXXX; and what problems have you had since using the software?*
- *Did you review other control software and if so what software?*
- *Was there training provided and was it adequate?*
- *How would you rate the documentation provided?*
- *Do you use the bar code to input job times, etc.?*
- *How do you input processing times currently?*
- *Do you have anything you would like to share with me, problems that may have occurred?*

### *5.8.1 System Hardware Requirements*

Once a software package has been chosen, a review of the sales documentation provided by each software company should provide information on what the system requirements are for running their software. Based on a review of current (8/97) software, the following is given as an example. This system should be capable of running most current PC manufacturing planning and control software. Computer System Requirements:

233 MHZ Processor

64 MB RAM

6.4 GB Hard Drive

32X CD ROM

56 K Modem

1.44 MB Floppy Disk

15" Monitor

Network Card

HP Laserjet Printer

Bar Code Guns

Automated Tape Backup System

### *5.8.2 System Users*

To realize the full potential of an MPC computerized system, many business functions need access to the system database, they include: Management, Engineering, Shop Manager, Production Control, Purchasing, Receiving/Inventory, and Accounts Payable. The structure of each individual company, the location of offices and the number of separate individuals that require access to the system will determine this. Ideally, each of those business functions listed above should have access to a system. However, this could result in purchasing as many as eight data systems and a network server. To reduce the initial investment costs it is recommended that the results from step one, "Determine if an MPC system will benefit your company" be reviewed. By reviewing which business areas are estimated to provide the greatest benefit, a priority implementation plan can be developed and a phased implementation defined. It is important to stress that the successful use of any MPC computerized system is determined by the quality of the data that the system provides. If the key personnel required to access the system to perform their duties cannot effectively perform those duties because the system is not available or the system is not easy to access, they will find other methods to perform their duties and the MPC system will not be effective. Therefore, it is important that key users have easy access to desktop systems.

### *5.8.3 Bar Code Systems*

One effective method for tracking job data through the shop is with the use of bar code systems. Ideally, each work center would have its own bar code which would allow operators to scan the shop router (for the job number), their employee number and the work center number where the job is to be processed. This would be done as the job is started and after completion of the job. Time and cost data would then be tracked for that job by the MPC computerized system. The cost for purchasing bar code systems for each work center, estimated to be $300 per system, can substantially increase the initial investment costs. It is therefore recommended that only those work centers that are estimated to provide the best initial benefit be configured initially. However, an effort to provide each department with one system should be made. During the S & R case study a comparison of the costs of using time cards, and the associated data entry involved, indicated a pay-back period of close to one year for the purchase of four bar code systems.

If there are high amperage lines used by welding machines or machine tools, the specific location of each bar code system and the cable type should be determined after consultation with the bar code supplier. It is again stressed that if production employees do not have easy access to the bar coders, production time will be reduced. If additional funds are available, purchasing bar coders for each work center will increase the efficiency of the system.

## 5.9 Assess the Educational and Training Needs of Employees

Based on the survey of job shops, it was found that most job shops acquired their employee training on an informal basis. The survey data showed that employees working in shop floor control, only 10.6% had received college level training in this area. Approximately 8.6% had received vendor training and 80.8% had received no formal training. While it is true that most MPC system software companies do include training, it is usually limited and is typically only provided for one or two employees. To better prepare employees to effectively use an MPC system it is recommend that some formal training be provided. This formal training can usually be provided through local community colleges.

During the S & R case study, Blue Mountain Community College [19] (BMCC) (the community college located nearest to the S & R plant) was contacted about the possibility of offering a course for S & R Industries, and after discussing the need for this training with the appropriate dean, a dialog was started. BMCC was able to provide this training and also suggested that the course be offered at the S & R site during the evening when most employees were available[2]. A course, "Introduction to Manufacturing Methods and Control", was developed. The objectives for this introductory course, which are described on the next page, are based on discussion with S & R employees and the terminology used in the user manuals of the software packages that were reviewed. A questionnaire could determine if current employees understand this terminology and the objectives, and would aid in identifying the appropriate training needed. This course (Suggested Title "Introduction to Manufacturing Methods and Control") should provide the shop floor employees with an overview of the following manufacturing functions so that they will

[2]An introductory manufacturing course was offered by BMCC at the S & R plant during the fall of 1995.

better understand the objectives and functions of a typical MPC computerized system. After taking this introductory course, employees should be able to:

Define the following manufacturing functions associated with a job shop, including:

- Plant Capacity, Work Center capacity, Scheduling, forward and backward scheduling, finite and infinite scheduling, Setup-time, Run-time.

Understand the importance and definition of the following terms:

- Productivity, Efficiency, Material Handling, Value Adding Process, Tooling Costs, Direct and Indirect labor costs, overhead, burden.

Be familiar with the following Inventory terms:

- Inventory, Inventory Control, Inventory Costs, Stock Unit, Usage Unit, Purchase Unit, Lead-time, Economic Order Quantity, Shop Materials.

Understand the importance of controlling the following functions:

- Man Hours, Job Tracking, Real-Time Data, Process Planning, Shop Router, Expediting, Lead-time, Work in process (WIP), Bill of Material (BOM).

Define and understand the following Quality terms:

- Quality, Quality Control, Inspection, and the costs associated with these terms.

## 5.10 Determining Implementation Costs

To give a better understanding of the costs associated with the implementation of an MPC system the following example is provided. It should be noted that these costs were prepared in September, 1998, and that hardware costs are continually changing, (typically, most PC computer systems are becoming less expensive each year). This cost estimate does not included the cost of loss to production. Productivity will obviously be effected if employees are required to collect system data and input this data to the system in addition to their regularly scheduled workload.

The initial investment costs for the S & R case study are provided as an example. Costs for hardware, software and training are listed. These costs include the purchase of five (5) computer systems, four (4) data systems and one (1) network file server system, JobBOSS Windows 98 MPC software, the network software, and additional recommended hardware. The hardware and software necessary for the bar code data collection system, the cost to send two employees for three days training and the community college cost for the suggested introductory course are included. These costs could be significantly less if a company is currently using a computerized system for other business functions and can use those computers for the new MPC system. The costs are listed below.

The following example of system costs are updated from the original S & R project and reflect costs for September, 1998.

| | |
|---|---|
| Five Pentium computers, 233MHZ 64MB RAM, SVGA color monitors and 6.4 Giga-byte hard drives. Total cost each $1,500.00 x 5 | $7,500.00 |
| Windows 98 software $100 x 5 | $ 500.00 |
| Network cards $100 x 5 | $ 500.00 |
| Automated Tape Backup | $ 500.00 |
| Printer: HP LaserJet $450 x 2 | $ 900.00 |
| JobBOSS software (5-user network)[3] | $13,000.00 |
| Data Collection: Includes 4 bar code guns: | $ 5,300.00 |

[3] This cost is for the Job Control software package that provided: quoting, SFC, labor reporting, cost analysis, order processing, material control, shipping and system administration. Other add on options include: Invoicing, accounts receivable, general ledger, payroll and archiving. A 5 user system cost is $13,000 and a 10 user system costs $20,000. Each additional seat is $1,000.

| | |
|---|---|
| System Setup and Test | $ 4,000.00 |
| Training: | |
| User training. Community College 3 Credit Class, 10 people X $150.00 | $ 1,500.00 |
| Software Training provided by software supplier (no charge for two) | |
| Travel: | |
| Round trip airfare $500.00 each x 2 | $ 1,000.00 |
| 4 nights room and board $150.00 each x 2 x 4 | $ 1,200.00 |
| **Grand total** | $35,900.00 |

It is possible that many shops will have the computer systems and the network software currently in place to run this type of system. This would reduce the initial investment considerably.

## 5.11 Developing an Implementation Timeline

Before an implementation timeline can be developed a list of all the activities that need to be performed must be generated. Because these activities will vary depending on the specific business areas that the software is purchased to control, the S & R case study example is again provided. The tasks are broken down into three major phases:

- Hardware selection and data preparation
- Data input
- Conduct full Implementation

It is noted that this implementation timeframe can vary greatly depending on the current activities of the company performing the implementation. The estimate provided to S & R suggested an implementation timeframe of six (6) months. This was due partially to their production capacity and work load at that time. However, it should also be noted that one company, Buyken Industries [20], after purchasing JobBOSS system software and installing it on to their computers, completed this task in one week and was completely functional in ten weeks. (see Appendix C for more information) They did however, dedicate a large task force to achieve implementation in that short time frame which drastically affected production during that week. The six month time frame is suggested so that production can be maintained while the system is brought online and includes two months for choosing and purchasing the hardware and software. Each task is defined and allocated a start and end date and is planned using a Gantt chart, a sample of which is shown in Figure 11 on the next page. The project leader will need to motivate each individual responsible for a particular task, to complete their specified task on time so that the next task can then be completed.

### *5.11.1 Hardware Selection and Data Preparation*

During this first implementation phase new computers[4] will be chosen and purchased and the necessary data collected and prepared for future input to the system. The type of system needed should be defined by the choice of software, see page 59 for this information. Before the software can function correctly and provide the control previously discussed, data needs to be collected and input to the system.

The increased control provided by an MPC system is partially attributed to the planning involved with such a system. Therefore, it is necessary to standardize methods that will conform to the way the system functions. Planning in this phase is crucial, as most systems are very specific about the format of the data that will be input. Work centers must be defined, numbered and the capacity for each estimated.

[4]It is assumed that computers are not currently available and will need to be purchased for the new MPC system.

## Production Control Implementation Schedule

| Months | | | | 1 | | | | 2 | | | | 3 | | | | 4 | | | | 5 | | | | 6 | Department |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **TASK** Weeks | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | Responsibility |
| **Choose & Purchase Computer System** | | | | | | | | | | | | | | | | | | | | | | | | | Varies |
| **Prepare System Data** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Customers | | | | | | | | | | | | | | | | | | | | | | | | | Sales/Office |
| Vendors | | | | | | | | | | | | | | | | | | | | | | | | | Purchasing |
| Work Centers | | | | | | | | | | | | | | | | | | | | | | | | | Production |
| **Prepare Inventory Item Data** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Inventory Materials | | | | | | | | | | | | | | | | | | | | | | | | | Production/Purchasing |
| Inventory Parts | | | | | | | | | | | | | | | | | | | | | | | | | Purchasing/Inventory |
| Inventory Supplies | | | | | | | | | | | | | | | | | | | | | | | | | Inventory |
| Employees | | | | | | | | | | | | | | | | | | | | | | | | | Office |
| **System Setup (Hardware/Software)** | | | | | | | | | | | | | | | | | | | | | | | | | Vendor |
| Input Work Center Data | | | | | | | | | | | | | | | | | | | | | | | | | Production |
| Input Annual Shop Calendar | | | | | | | | | | | | | | | | | | | | | | | | | Management |
| Input Customer Data (Name/Code) | | | | | | | | | | | | | | | | | | | | | | | | | Sales/Office |
| Input Vendor Data (Name/Code) | | | | | | | | | | | | | | | | | | | | | | | | | Purchasing |
| **Input Inventory Item Data** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Inventory Materials | | | | | | | | | | | | | | | | | | | | | | | | | Production/Purchasing |
| Inventory Parts | | | | | | | | | | | | | | | | | | | | | | | | | Purchasing/Inventory |
| Inventory Supplies | | | | | | | | | | | | | | | | | | | | | | | | | Inventory |
| Input Employee Data | | | | | | | | | | | | | | | | | | | | | | | | | Office |
| Start Estimate New Jobs | | | | | | | | | | | | | | | | | | | | | | | | | Engineering/Management |
| Convert Estimate to Job | | | | | | | | | | | | | | | | | | | | | | | | | Production |
| Schedule New Jobs | | | | | | | | | | | | | | | | | | | | | | | | | Production |
| Produce PO's for Material/Part Buys | | | | | | | | | | | | | | | | | | | | | | | | | Purchasing |
| Receive Material/Parts to Inventory/System | | | | | | | | | | | | | | | | | | | | | | | | | Inventory |
| Process New Jobs | | | | | | | | | | | | | | | | | | | | | | | | | Production |
| Work Center Data Entry | | | | | | | | | | | | | | | | | | | | | | | | | Shop Floor Personnel |
| Shop Floor Reporting | | | | | | | | | | | | | | | | | | | | | | | | | Varies |
| Ship Finished Parts | | | | | | | | | | | | | | | | | | | | | | | | | Shipping |
| Access Job Efficiency Data | | | | | | | | | | | | | | | | | | | | | | | | | Management |

Figure 11. Implementation Schedule

Reviewing the MPC data format will help streamline this process, and using standard forms to collect this data will also help. Examples of typical formats for inputting data are described on pages 70 (figure 12) and 78 (figure 15), and a sample setup/run time data collection form is shown on page 71 (figure 13). The following section is included to give a better understanding of the typical information that an MPC computerized system requires. If the implementation team has a good understanding of this terminology, the type of data and the format that this data must follow, then this phase of the process will run more smoothly. Obviously, each software package functions differently, however, most will require similar methods that follow this example.

**Work Center Worksheet**

Data input by: ____________________ Date: ___/___/___

Please use the following format:

Work Center # (two digit) ______

Department # (two digit) ______

Description (eight char) ______________

Setup Labor rate (three digit period two digit) ________ . ____

Run Labor Rate (three digit period two digit) ________ . ____

Burden (Percent/Amount) Pct. (three digit) ______
Amt (three digit period two digit) ________ . ____

Capacity Hours per day (three digit) __________

Schedule Hours per day (two digit) ________

Queue Hours (two digit) ________

Type D>irect, I>ndirect, S>ub ___

Figure 12. Sample Work Center Data Format Form

**Sample Data Collection Form**

**Setup/Run Time Data**

Please use this form to gather preliminary data on setup/run time for each work center.

Setup is defined as [21] 1.) "The work required to change a specific machine, resource, work center, or line from making the last good piece of unit A to the first good piece of unit B. 2.) The refitting of equipment to neutralize the effects of the last lot produced and preparation of the equipment for production of the next scheduled item."

Run Time is defined as the total time necessary to process (cut, weld, paint etc.) a job or part. That includes loading a part to a fixture, processing the part, and unloading the part.

**Work Center Name** ______________________________________

**Job #** __________________________ **Date** _____________

**Part # (If available)** _________________________

**Short description of setup:** ___________________________________

_______________________________________________________

**Setup Time Data:**

**Start Time** __________________ **End Time** ___________________

**Short description of process:**

___________________________________

_______________________________________________________

**Run Time Data:**

**Start Time** ___________________ **End Time** ____________________

**Number of Parts Processed** ________

Figure 13. Sample Setup/Run-time data form

*5.11.1.1 Work Centers:*

A work center is defined as any piece of equipment, group or cell where a process or group of processes is performed. Work centers can be either in-house or a vendor process. An in-house work center could be a lathe, a welding station or a group of machines in a cell. A vendor work center could be a complete outside process such as heat-treatment. The objective is to break the work down into definable, manageable units. It is important to keep in mind that the more work centers that are defined the finer the control that can be achieved. However, there appears to be a point of diminishing returns, where shop floor personnel can spend too much time controlling and tracking jobs through the shop and less time actually manufacturing jobs. If there are too many work centers defined then production personnel will find themselves spending too much time tracking parts and inputting data to the system. The following section defines the information that must be collected for input to a typical MPC computerized system.

*5.11.1.2 Work Center Data:*

Setup Labor Rate: Setup is defined as [21] 1.) "The work required to change a specific machine, resource, work center, or line from making the last good piece of unit A to the first good piece of unit B. 2.) The refitting of equipment to neutralize the effects of the last lot produced and preparation of the equipment for production of the next scheduled item." The "setup labor rate" is the total cost per hour for this task.

Run Time Labor Rate: Run time is defined as the total time necessary to process (cut, weld, paint, heat-treat etc.) a job or part. That includes loading the part in a fixture, processing the part, and unloading the part. The "run time labor rate" is the total cost per hour for this task.

Burden: This cost is typically an additional cost based on the burden or overhead for the factory. Most software packages allow burden to be applied as a fixed amount (in dollars) per setup, or as a percentage of the setup time and run time costs.

Capacity Hours Per Day: If the software provides for infinite scheduling, the capacity for each work center (the hours per day that the work center is available) must be input to the system.

Schedule Hours Per Day: If the software provides for finite scheduling, the schedule hours per day can be input to the system to reflect the difference between the capacity based on what hours are available and what hours are typically used, i.e. a normal eight hour day might be the scheduled hours available but the capacity might be 24 hours per day if overtime is considered. Most systems will provide for either finite or infinite scheduling. JobBOSS also provided a "what if" option where both scheduling methods can be reviewed for optimization.

Labor Type: Most systems will allow the work performed on a work center to be defined as direct, indirect and subcontractor based on how tracking and labor costing is done.

Shop Router/Traveler: The shop router is the planning form of the system. Its accuracy will determine the cost accuracy of the finished part. Time spent preparing the shop router and accurately planning the part through the shop will be time saved, as this data is the basis for most MPC computerized system tracking, scheduling, and costing.

Most job shops use some form of shop router/traveler to provide the shop with the necessary information to process a part. A shop router contains process information on the part, a number that defines the operation to be performed at a specified work center, and a description of the operation. A typical MPC computerized system uses this information to calculate costs based on the total setup, run time, and burden for a part. This information is also used to describe what capacity has been allocated and what is available for each work center, and the schedule for each work center. This information can be viewed numerically and graphically using finite or infinite scheduling methods and can describe hourly, daily and monthly workloads.

Most MPC computerized system software provides for the input of shop router data automatically. A user simply chooses the work center and defines the setup and run times for a part or process. A brief or detailed operation description can be input depending on the complexity of the operation. The shop router information is then used to update the database and provide the necessary information to the other functions of the MPC system. The shop router can then be printed and included in the job release document with drawings and any other pertinent information for issue to production. One other advantage to using an MPC computerized system is the ability to produce Computer-Added Process Planning (CAPP). Existing process plans can easily be modified and quickly updated to produce accurate quotes for new jobs. A sample shop router is shown in Figure 14.

**SHOP ROUTER**

| | | |
|---|---|---|
| PO # : | Prepared By: | Sheet of |
| Job # : | Date: | |
| Part # : | Material Type: | |
| Drawing # : | Material Description: | |
| Part Description: | Revision # : | |
| Order Qty: | Customer # : | |
| Make Qty: | Customer Address: | |

| Work Center | Op # | Operation Description | Setuptime | Runtime | Tooling | Misc | Location |
|---|---|---|---|---|---|---|---|
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Figure 14. Sample Shop Router.

This particular router also contains information on tooling used for the part, and where the part will be located in the plant following each operation. There is also information on the material used for the manufacture of this part

### *5.11.2 Inventory Data*

Another set of data that is critical to the effective function of the MPC computerized system is inventory information. This section of the database allows raw material, finished goods, sub-assemblies, and purchased parts to be tracked and the costs associated applied to jobs. Parts can typically be identified by number or by name. It is suggested that the implementation team look at the benefits of group technology and part families before simple numbers are designated to these parts. Options for retrieval of data, based on group technology systems, will provide many advantages when the system is used and fully functional. The following is an example of the type of inventory data that will need to be gathered for input to the system:

Item Number: Each item within the database must be assigned an item number, whether the item is a detail part, an assembly, a raw or finished material type, a purchased part, all will need a unique item number so that they can be tracked within the system.

Purchase Price Per: Most systems will record the purchase price for an item i.e. per unit, per 100 units or 1000 units.

Primary Vendor: Name of the vendor that item is typically purchased from. Can provide information to quickly generate a P.O. for an item.

Last Vendor: The vendor that each item was purchased from last.

Lead Time: Time lapse from placing an order to receiving the order. This will be used to automatically flag parts that are running low based on current use rates and the estimated lead time.

Purchase Unit: The units that the item is purchased in; lbs, feet, bars, number.

Reorder Point: The system will use this number to automatically inform the user when stock reaches a specified level, i.e. the reorder point.

Vendor/Customer Information: Additional information on each vendor and customer is required and will be used to generate semi-automatic purchase orders, billing information and shipping documentation. A sample inventory data collection forms is shown in Figure 15 on the next page:

**Sample Inventory Item Master Form**

Item number __________________________ 16 character

Item Type __ R>aw, F>inished  Prod Class _______ 4 character

Item Description __________________________ 20 character

Stock unit ________ 6 character

Extended Description _____________________________ 16 character

Location ________ 4 character

Standard Cost ____________________ . _____ 7 character . 2 character

Price Per __ E>ach, C>100, M>1000

Usage Unit _______________ 5 character

Usage Factor ___________ . _________ 5 character . 4 character

Part Number ____________________________________16 character

Revision ___________ 3 character

Primary Vendor ____________________ 8 character

Last Vendor ______________________ 8 character

Lead Time __________ 3 character

Purchase Unit _______________ 6 character

Reorder Point _________________ 7 character

Purchase Factor ______________ . _____________ 5 character . 4 character

Selling Price _______________ . _____ 7 character . 2 character

Average Cost _______________ . _____ 7 character . 2 character

Figure 15. Sample Inventory Data Format Form

### *5.11.3 Data Input*

By the time all the required data has been calculated and collected, the new computer network should be set up and configured for the appropriate software. The data that was collected and prepared in phase one will now be input to the system. This can require many hours of data entry work which can easily be accomplished by data entry part-time help. Knowing ahead of time what data is needed and the format of that data can make this phase run smoothly. The software supplier should be consulted for help during this phase, as the system will not be usable until the basic data has been input.

### *5.11.4 Conduct Full Implementation*

The third and final phase of the implementation process will allow the first new quotes to be estimated and processed through the system. This final phase will be slow to start because adequate time must be allowed for each of the new steps to be tested for a short time before the next step is accomplished. This will allow adjustments for tuning the system. However, the system will not be completely effective until all the jobs are input to the system. It is estimated that after the sixth month (this time will depend on the size of each shop and the number of items in the system) all the initial bugs should be fixed and production can be controlled by the new software.

During each of the three implementation phases, overall goals that are outlined in the plan should define what each employee is responsible for and why it is important for this implementation to be successful. Employees must understand what they are doing and why it is important for this to be done accurately. Changing the way a company functions can be successful if employees believe what is being done will benefit them and the company in general. It is the responsibility of management to provide motivation to its employees in this area.

During the implementation process some employee tasks will take many days to complete and others will only take hours. The success of the overall project depends on each individual performing their task on time and correctly. If necessary, help should be provided, in the form of data entry personnel, to individuals who are responsible for tasks that will require many days to complete. Help can also be provided by sharing that employee's daily job activities when working on the implementation of the MPC system.

Once the system is on-line and functional, employees must be encouraged to use the system. Training can be formal, that is training provided by the software company, or it can be informal, training provided by other employees who have been recently trained themselves. It is important that new users be encouraged to use the system as often as possible so that they become familiar with the screens and printouts. It may not be possible for all employees to achieve the same level of expertise in the same time. Some will require more time to learn how to use a function. Help sessions should be planned. When one employee provides new insight in an area that is important they should be rewarded and encouraged to share how they did what they did with other users. It may take several months before the system is used efficiently by everybody.

After the system has been used for an extended length of time (6 months) management will need to review what is being done and assess where improvements can be made. Most software comes with one year system support and a call to the support people could provide new ideas on how using the software could be modified to provide improved manufacturing control. This information can then be passed onto the employees.

## 5.12 Measure Project Performance

The implementation of this formal MPC system should not only provide for improved system control, it should also lead to improved productivity. To measure any change in productivity, a base value using the current production system, must be determined. Then, at a later date when the new MPC system is being fully utilized, new data can be gathered and comparisons made. A review of the following areas is suggested:

- A measure of the percentage of jobs that are currently shipped on schedule. This data should include the estimated hours and the actual hours required for completion of the job. If the job is not shipped on schedule, some reference to the number of days that the job is late should be made and documentation describing the reason for the lateness should be noted.

- Determine the percentage of the parts or materials that are currently shipped using overnight delivery costs that could be shipped by less expensive means.

- Determine the number of unplanned overtime hours worked as a percentage of the total hours necessary for completion of the job.

- Determine the number of hours of rework performed as a percentage of the total hours worked to complete the job.

The collection and evaluation of this data will allow future changes in productivity to be measured, which should provide an effective method to determine how well the new MPC system is performing.

# 6. MPC System Benefits

A brief description of the benefits were discussed at the beginning of chapter five. The following section expands on those possible benefits.

## 6.1 Quoting

Many new jobs that require a quote are similar to previous jobs and could use existing quote data to create a new quote, thereby saving estimating time. Typically, paper filing methods do not make it easy to access data, relying on individuals to remember similarities between previous jobs so that they can review and maybe use or modify existing quotes. Most computerized systems allow access to data by referencing part type, part name, vender name, part number, and production date to identify the similarities between parts. Some computerized systems use group technology methods to simplify this part identification. Once an estimator has identified the similarities between a previous part quote and a new part quote the advantages are extensive.

A computerized system provides access to all the important information about the existing part or job, including the process plan that defines the processes that were used to produce the part or parts. It provides information on what materials were used, where the materials were purchased, the cost of materials and many other associated data costs. Important data on problems that might have occurred during production, can also be reviewed so that the same mistakes are not repeated. Data on the quoted cost of all facets of production can be compared to the actual costs. This information can then be used to improve the new quote. Granted, this can be done with a good paper control system if it is managed well, however, most paper systems store data for different production functions in different locations or offices, which means that the user must be persistent in seeking out the existing data required to compare any new quote. Having an easily accessed computerized database can place this information at the fingertips of estimators who will then be more likely to take advantage of the existing data.

## 6.2 Scheduling

Most MPC system software packages provide some scheduling techniques where jobs can be scheduled using a variety of options. Typically both finite and infinite scheduling is available but on some systems only infinite scheduling can be performed. The advantages to using one of these two methods allows a user to manipulate many different schedule options and quickly see the results. For example, a system that provided infinite scheduling methods would typically allow both forward and backward scheduling where a user could quickly input the required start or promised ship dates and then view graphical data of the required capacity on each of the affected work centers. This graphical and numerical data can be calculated and displayed by month, week, day, and hour for individual work centers on many systems.

On systems that provide finite scheduling methods, where scheduling can only be done to 100% of capacity, scheduling can be based on priority codes, ship dates, priority start dates and remaining hours, to maximize the efficiency of the shop. One system reviewed provided a "what if" option that allowed a user to quickly review many different scheduling options and make changes to optimize production. The scheduling options provided by this "what if" function would be very time consuming if the calculations were to be done manually.

## 6.3 Capacity

By reviewing the schedule of critical work centers, more effective estimating can also be accomplished. If a new quote is being prepared and the resulting work load from this new quote requires overtime, added costs for this overtime can be included in the quote. A quick review of current and future capacity based on the scheduled workload at specific work centers will reveal this critical over capacity situation. The "what if" scheduling options could also be used to rework the schedule to find ways to reduce the need for overtime. The capacity data can also be used to plan maintenance scheduling at times that will create the least interruption to production. Access to past work center utilization data can help plan for the future. Historic information on setup times, run times, and maintenance can all be provided by most control systems. This data can be very valuable for future capacity planning.

## 6.4 Shop Router/Process Planning

One of the major advantages to using a computerized control system is in the use of computer-aided process planning. Process planning can be very time consuming and often requires the duplication of methods that are used to produce many similar parts. The ability to access previous shop routers and use the existing process planning for new jobs by simply copying the data or by modifying the data, can save time. This can be done by using group technology part identification methods or by using standardized filing methods where like parts can be easily identified. The filing method used should make it easy to conduct a database search to find all parts previously processed that are similar to the part currently being quoted or planned. For example, a typical job shop part for a machine shop might be to produce a variety of shafts. Each shaft might be a different length and diameter but the processing steps necessary to produce these shafts might be identical. All shafts will start their processing by being routed through the materials shop, to the saw shop to the CNC turning area and then to deburr and finally to inspection. Each of the sequenced operations identifies specific work centers and production methods that are often identical. By using existing shop router information from the database the planning work load can be reduced.

## 6.5 Material Costing

Most control packages will include a materials package that will quickly calculate the materials cost for batches of parts, although this is not typically a complex calculation and can easily be done by hand. The advantage of the computer, and its ability to calculate many options quickly, will often allow better analysis of materials utilization methods and cost considerations. Once the cost information for a specific part is input to the system, many "what if" options such as discount purchases for variable purchase amounts, cutting charges, shipping charges, scrap rates, and material burdens can quickly be reviewed for the most cost effective option. These material costs can also be filed for review when new material quotes are needed.

## 6.6 Data Collection

The success of any MPC system is ultimately determined by the quality of the data that the system provides. If the data is collected weekly, by the use of time cards, it will not be possible to effectively control production that requires less than one week to complete. Another computer option is to use some form of bar code data entry system to collect the necessary production data. A simple calculation, based on S & R's requirements, indicated a payback period of one year when costs of manually entering the data and using four bar code systems were compared. In addition, the use of a bar code data entry system would also allow real-time data access that would provide improved control in most instances. The timely entry of production data is what allows most shop floor systems to be effectively used for day to day evaluation and control. The advantages to entering the data using the bar code systems, accuracy and real-time data feedback for example, more than warrants the investment. See investment costs on page 65 for more detail.

## 6.7 Inventory Control

Most systems provide comprehensive inventory control that allows a user to control raw material, finished goods and purchased parts. A real-time balance of raw material and finished parts is maintained and can be accessed at any network station. Costs of material or parts can be maintained by standard, average or last cost options. Parts that are used frequently can be identified so that the system automatically prompts when stocks are low and need to be reordered. Parts or material that are in stock can be assigned to specific jobs indicating that they are in stock but assigned to a job. An annual usage report indicating the use of specified material or parts each month can be accessed.

# 7. Conclusion

A methodology to address the manufacturing control requirements of small to medium size job shops has been developed and described. The original assumption that was made, based on the case study at S & R Industries, indicating the need for this plan has been confirmed both by the literature and by the job shop survey. Furthermore, there is also evidence of the need for job shops to use computerized shop floor control software, other than MRP system software, that will control the everyday tasks that most production facilities encounter. These included quoting, scheduling, capacity planning, inventory control, shipping, receiving and P.O. and billing paperwork generation.

A number of software packages that provide these capabilities were reviewed and found to be favorably accepted by the companies using them. These software packages appear to provide the type of control necessary at a reasonable cost to the users. The literature indicates that about 70% of job shops use computers but that only 30% use computers for shop floor control. The survey data did not completely agree with this and indicated that more than 50% were currently using computers in some area for shop floor control. Note: the author considers the 50% that are not using computerized control methods to be a significant number. This discrepancy in data could be due to the fact that many job shops in Washington and Oregon, where the survey was conducted, contract with the aerospace industry where shop floor control and ISO9000 documentation are more formally applied.

It is hoped that the current plan and methodology will provide the impetus for small job shop companies to move from an informal to a more formal computerized shop floor control system.

# 8. Recommended Future Research

There are two areas where there appears to be a need for further research. These areas are outlined below:

## 8.1 Software Needs

The literature reviewed for this project indicated that MRP and MRP II software does not currently provide the type of effective shop floor control that most job shops require. There are a number of new software programs that are under development which are designed to link the MRP, the MPS and the shop floor activities together into one integrated package. Will these software packages, when developed, provide the type of control needed by most job shops, or will they be too complex and sophisticated for most, based on their limited resources, to use? Further research is needed to determine more specifically what type of software best fits the needs of these smaller job shop companies. Is there a need to control all business activities in a completely integrated package that will allow forecasting, MPS, MRP, inventory control and SFC?

## 8.2 Education of Shop Floor Control Personnel

From the survey data and the literature reviewed there appears to be a major gap developing between the types of shop floor control research that is being conducted and what is being used on the shop floor. Scheduling algorithms for example, are capable of solving the most complex classroom scheduling problems. My question is, are these complex algorithms useful to everyday job shops where variables can change by the hour? A closer look at the daily activities of most job shops should provide research with the answer to this question. Another area of interest relates the education of shop floor personnel (80% of shop floor managers have not received any formal training in shop floor control). Does this indicate that standard scheduling methods, JIT processing, etc. that are typically taught in most college engineering classes are not being used by most companies? How can we get this knowledge across to these managers? Are these companies aware of the benefits provided by these methods or are these companies for other reasons not using this information?

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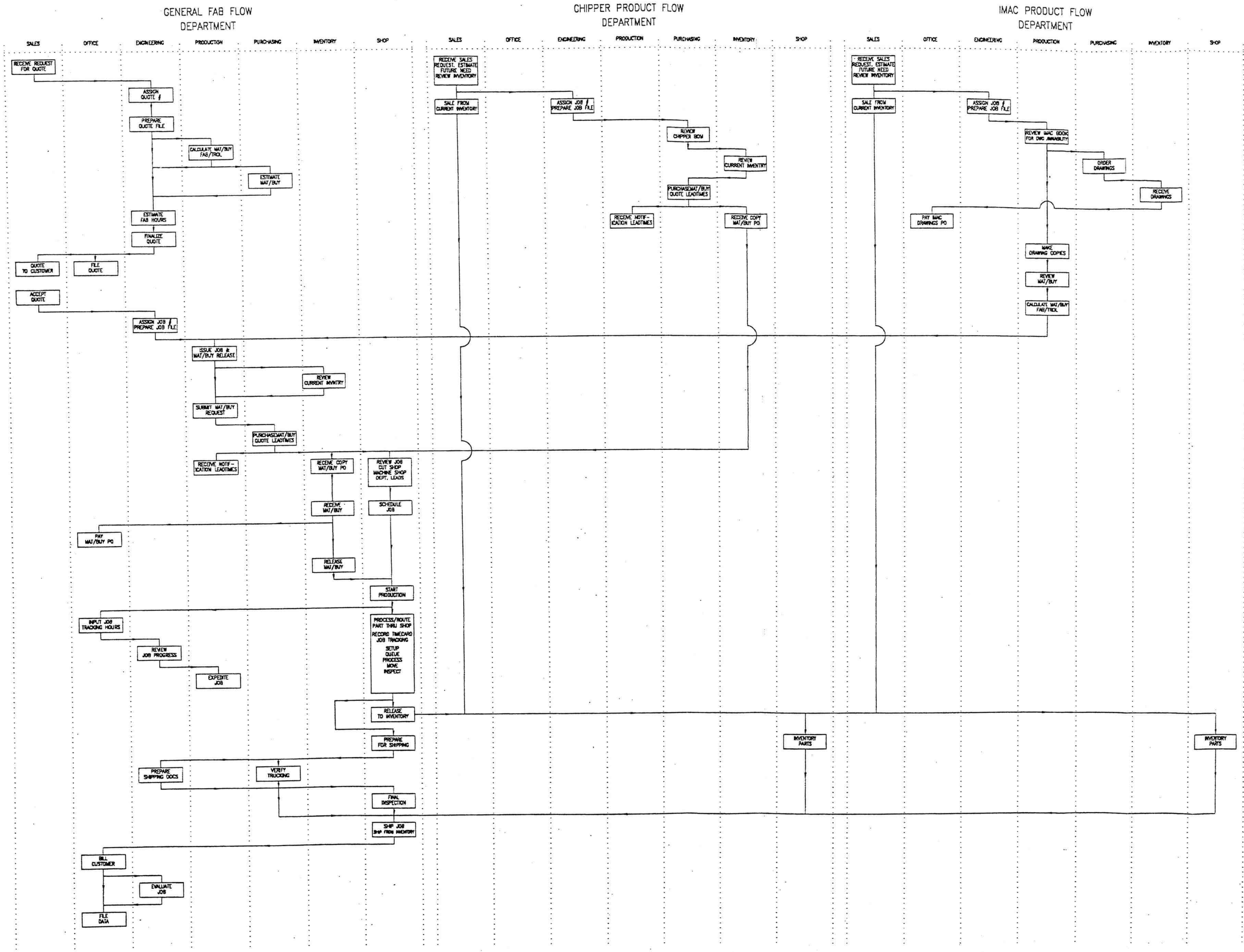
# APPENDICES

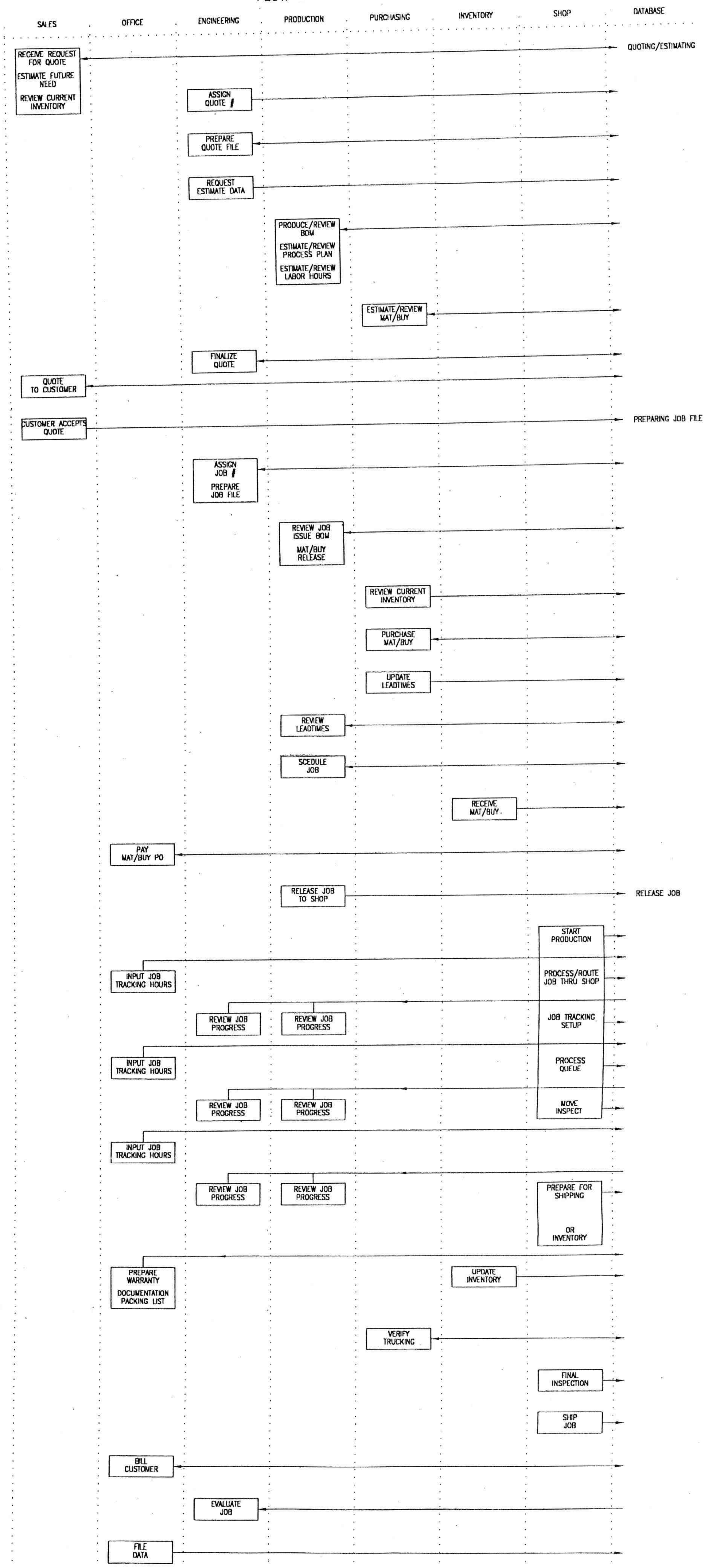
# APPENDIX A



GENERAL FAB FLOW DEPARTMENT
SALES
OFFICE
ENGINEERING
PRODUCTION
PURCHASING
INVENTORY
SHOP
RECEIVE REQUEST FOR QUOTE
ASSIGN QUOTE #
PREPARE QUOTE FILE
CALCULATE MAT/BUY FAB/TROL
ESTIMATE MAT/BUY
ESTIMATE FAB HOURS
FINALIZE QUOTE
QUOTE TO CUSTOMER
FILE QUOTE
ACCEPT QUOTE
ASSIGN JOB # PREPARE JOB FILE
ISSUE JOB & MAT/BUY RELEASE
REVIEW CURRENT INVNTRY
SUBMIT MAT/BUY REQUEST
PURCHASEMAT/BUY QUOTE LEADTIMES
RECEIVE NOTIF-ICATION LEADTIMES
RECEIVE COPY MAT/BUY PO
REVIEW JOB CUT SHOP MACHINE SHOP DEPT. LEADS
RECEIVE MAT/BUY
SCHEDULE JOB
PAY MAT/BUY PO
RELEASE MAT/BUY
START PRODUCTION
INPUT JOB TRACKING HOURS
PROCESS/ROUTE PART THRU SHOP RECORD TIMECARD JOB TRACKING SETUP QUEUE PROCESS MOVE INSPECT
REVIEW JOB PROGRESS
EXPEDITE JOB
RELEASE TO INVENTORY
PREPARE FOR SHIPPING
PREPARE SHIPPING DOCS
VERIFY TRUCKING
FINAL INSPECTION
SHIP JOB SHIP FROM INVENTORY
BILL CUSTOMER
EVALUATE JOB
FILE DATA
CHIPPER PRODUCT FLOW DEPARTMENT
SALES
OFFICE
ENGINEERING
PRODUCTION
PURCHASING
INVENTORY
SHOP
RECEIVE SALES REQUEST, ESTIMATE FUTURE NEED REVIEW INVENTORY
SALE FROM CURRENT INVENTORY
ASSIGN JOB # PREPARE JOB FILE
REVIEW CHIPPER BOM
REVIEW CURRENT INVENTRY
PURCHASEMAT/BUY QUOTE LEADTIMES
RECEIVE NOTIF-ICATION LEADTIMES
RECEIVE COPY MAT/BUY PO
INVENTORY PARTS
IMAC PRODUCT FLOW DEPARTMENT
SALES
OFFICE
ENGINEERING
PRODUCTION
PURCHASING
INVENTORY
SHOP
RECEIVE SALES REQUEST, ESTIMATE FUTURE NEED REVIEW INVENTORY
SALE FROM CURRENT INVENTORY
ASSIGN JOB # PREPARE JOB FILE
REVIEW IMAC BOOK FOR DWG AVAILABILITY
ORDER DRAWINGS
RECEIVE DRAWINGS
PAY IMAC DRAWINGS PO
MAKE DRAWING COPIES
REVIEW MAT/BUY
CALCULATE MAT/BUY FAB/TROL
INVENTORY PARTS

# APPENDIX B

# PROPOSED PRODUCTION CONTROL FLOW DIAGRAM



# APPENDIX C

JoBBOSS Software Review

Summary of interviews with JoBBOSS users, Mark DeLaurenti at Buyken Industries, Kent, WA. and Michelle Duppa at Cascade Fabrication, Eugene, OR. See the individual interview summaries for more detail on how they are currently using JoBBOSS.

Buyken Industries and Cached Fabrication are both job shops similar in size to S & R Industries. They appear to have successfully implemented JoBBOSS and are currently happy with the way it works.

After talking with both Mark and Michelle I feel more confident that JoBBOSS will do what S & R needs. Both individuals, especially Mark, were very happy with the software, what it would do and the help provided by JoBBOSS. Each company has approximately ten people currently using the software on a Novel network.

They indicated that the documentation was very good, and with very little formal training from JoBBOSS, their personnel had trained themselves to use the software.

One of the major advantage of using the software was that the estimates/quotes can be produced quickly using standardized templates and past estimate/quote data. Mark, specifically, indicated that this was now being done in one tenth the time it used to take. This estimate/quote information can then be quickly translated into a job with the minimal of additional work.

Being able to schedule and track jobs through the shop is another major advantage because JoBBOSS allows finite or infinite scheduling to be done. This allows capacity to be easily reviewed for the shop based on individual work centers. This will allow S & R to review the capacity and then prepare better estimates/quotes.

Both Mark and Michelle felt that for the price, JoBBOSS software provides the necessary tools that allows their company to control its production and related functions.

I have asked JoBBOSS to forward me any information that will allow me to review their suggested installation and setup procedures. This will allow me to develop a control system that not only fits S & R's needs, but will be the foundation for any computerized control system.

I will review other software and compare it with JoBBOSS before making any final recommendation.

Note:

Initial my intent was to review the current system at S & R and define a control system that was either a paper or a computerized system. However, it is becoming apparent that the advantages of a computerized system, one that is capable of handling the database necessary for controlling S & R's production, far outweigh a paper system. At this point I am leaning towards a computerized control system.

# APPENDIX D

DATE 8/03/95

TO: Holly Griner, JoBBOSS Software

FROM: Bob Maplestone, S & R Industries

SUBJECT: Demo Information

Holly, we are looking forward to seeing the on-line demo on Monday and hope that the JoBBOSS software will demonstrate its ability to control our production system. I have enclosed the dummy job for the demo. Most of the jobs at S & R are assembly type jobs where many part make up a product. The enclosed demo information should allow us to see how JoBBOSS will fit S & R's needs.

Note that all the numbers are estimated and that setup times are per job and the run times are per part.

Demo Info:
Job # 9519 Bridge Assembly Qty Req. 5
See attached seven sheets for each part detail.

**PARTS LIST**

| Item # | Part # | Description | Qty |
|---|---|---|---|
| 1 | 9519-1 | J Channel 10x6.5#x28ft | 1 |
| 2 | 9619-2 | WFlange 14x22#x38ft | 1 |
| 3 | 9519-13 | Angle2x2x1/4x14" | 2 |
| 4 | 9519-14 | Angle2x2x1/4x32" | 1 |
| 5 | 9519-15 | Angle2x2x1/4x18" | 1 |
| 6 | NUT7/8NC | Nylock nut 7/8NC | 16 |

The angle material is a typical material that S & R uses frequently. We are interested to see how a change in cost of this material will easily be reflected in the total cost of the job should another order be received for this job in the future.

Thanks for all your help, I will be at S & R by 10:00 am Monday if you have any question.

memo3.s-r

**ISO 9000 CERTIFIED**

## JobBOSS Sample Job Form

Your Name: BOB MAPLESTONE
Your Company's Name: S & R
Phone #: (502) 523 - 5952
Fax #: ( ) ____ - ______

Job #: 9519
Part #: 9519 ASSY
Description: BRIDGE ASSY
Selling Price: $1210.97 EACH
Run Quantity or Quantities: 5
Shop Rate or Labor/Burden: 25%

Type of Material: (Indicate if Purchased Direct or from Inventory)
— Cost:
Cost:

Subcontract SVC: — Cost:
Cost:
Cost:
Cost:

Other: USES PARTS 9519-1, -2, -13, Cost:
-14, -15 & NUT 7/ENC Cost:

**Routing**

List sequence of operations and their estimated and actual run times. If you do not use routings, indicate the total time of the job.

**Circle One:** Parts/Hour Sec/Part Min/Part Hours/Piece

30/5 + 60 = 66

| Operation | Shop Rate | PER JOB Setup "Hours" | * PER PART Estimated Run Time | Actual Run Time or | Total PER PART Time |
|---|---|---|---|---|---|
| 10 FAB | 14.00 | .5 | 60 | ? | 66 MIN |
| 20 WELD | 16.00 | .25 | 45 | ? | 48 MIN |
| 30 CLEAN | 7.00 | .25 | 10 | | 13 MIN |
| 40 INSP | 16.00 | .25 | 10 | | 13 MIN |
| 50 SHIP | 10.00 | .5 | 10 | | 16 MIN |
| | | | | | |
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**ISO 9000 CERTIFIED**

## JobBOSS Sample Job Form

Your Name: BOB
Your Company's Name: S&R
Phone #: ( ) _____ - _______
Fax #: ( ) _____ - _______

Job #: 9519-A
Part #: 9519-1
Description: J CHAN
Selling Price: —
Run Quantity or Quantities: 1
Shop Rate or Labor/Burden: 25%

Type of Material: (Indicate if Purchased Direct or from Inventory)

| | | |
|---|---|---|
| | J CHANNEL 10 X 6.5# 28 FT | Cost: 54.6 |
| | PURCHASED DIRECT | Cost: |
| Subcontract SVC: | | Cost: |
| | HEAT - TREAT | Cost: 15.00 |
| | | Cost: |
| | | Cost: |
| Other: | | Cost: |
| | | Cost: |

### Routing

List sequence of operations and their estimated and actual run times. If you do not use routings, indicate the total time of the job.

**Circle One:** Parts/Hour Sec/Part Min/Part Hours/Piece

| Operation | Shop Rate | PER SAW Setup Hours | PER PART Estimated Run Time | Actual Run Time or | PER PART Total Time |
|---|---|---|---|---|---|
| 10 BSAW | 13-0 | .5 | 10 | ? | 40 |
| 20 DEBURR | 8.0 | .25 | 5 | | 20 |
| | | | | | |
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**ISO 9000 CERTIFIED**

## JobBOSS Sample Job Form

Your Name: BOB
Your Company's Name: S & R
Phone #: ( ) ____ - ______
Fax #: ( ) ____ - ______

Job #: 9519-B
Part #: 9519-2
Description: W FLANGE BRKT
Selling Price: —
Run Quantity or Quantities: 1
Shop Rate or Labor/Burden: 250%

Type of Material: (Indicate if Purchased Direct or from Inventory)
WIDE FLANGE 14X22# 38FT Cost: 205.80
PURCHASED DIRECT Cost:

Subcontract SVC: Cost:
Cost:
Cost:
Cost:

Other: Cost:
Cost:

**Routing**

List sequence of operations and their estimated and actual run times. If you do not use routings, indicate the total time of the job.

**Circle One:** Parts/Hour Sec/Part Min/Part Hours/Piece

| Operation | Shop Rate | Setup Hours | PER PART Estimated Run Time | Actual Run Time or | PER PART Total Time |
|---|---|---|---|---|---|
| 10 BSAW | 13.00 | .5 | 15 | | 45 |
| 20 DEBURR | 8.00 | .25 | 10 | | 35 |
| 30 DRILL | 12.00 | .25 | 5 | | 20 |
| | | | | | |
| | | | | | |
| | | | | | |
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| | | | | | |

JobBOSS SOFTWARE
WE'RE PART OF YOUR SHOP
ISO 9000 CERTIFIED

## JobBOSS Sample Job Form

Your Name: BoB
Your Company's Name: S E R
Phone #: ( ) ____ - ______
Fax #: ( ) ____ - ______

Job #: 9519-C
Part #: 9519-13
Description: ANGLE BRACE
Selling Price: —
Run Quantity or Quantities: 2
Shop Rate or Labor/Burden: 25%

Type of Material: (Indicate if Purchased Direct or from Inventory)
ANGLE 2x2x1/4 x 14" Cost: 1.00
FROM INVENTORY Cost: ______
Subcontract SVC: ______ Cost: ______
______ Cost: ______
______ Cost: ______
______ Cost: ______
Other: ______ Cost: ______
______ Cost: ______

### Routing

List sequence of operations and their estimated and actual run times. If you do not use routings, indicate the total time of the job.

**Circle One:** Parts/Hour Sec/Part Min/Part Hours/Piece

| Operation | Shop Rate | PER JOB Setup Hours | PER PART Estimated Run Time | Actual Run Time or | PER PART Total Time |
|---|---|---|---|---|---|
| 10 BSAW | 13.00 | .5 | 4 | | 19 |
| 20 DEBURR | 8.00 | .25 | 10 | | 18 |
| 30 DRILL | 12.00 | .25 | 5 | | 13 |
| | | | | | |
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**JobBOSS**
SOFTWARE
WE'RE PART OF YOUR SHOP
ISO 9000 CERTIFIED

## JobBOSS Sample Job Form

Your Name: BoB
Your Company's Name: SEC
Phone #: (    ) ____ - ______
Fax #: (    ) ____ - ______

Job #: 9519-D
Part #: 9519-14
Description: ANGLE BEKT
Selling Price: —
Run Quantity or Quantities: 1
Shop Rate or Labor/Burden: 25%

Type of Material: (Indicate if Purchased Direct or from Inventory)

| | | |
|---|---|---|
| | ANGLE 2×2×1/4×32" | Cost: 2.20 |
| | FROM INVENTORY | Cost: |
| Subcontract SVC: | | Cost: |
| | | Cost: |
| | | Cost: |
| | | Cost: |
| Other: | | Cost: |
| | | Cost: |

### Routing

List sequence of operations and their estimated and actual run times. If you do not use routings, indicate the total time of the job.

**Circle One:** Parts/Hour Sec/Part Min/Part Hours/Piece

| Operation | Shop Rate | PER SC Setup Hours | PER PART Estimated Run Time | Actual Run Time or | PER PART Total Time |
|---|---|---|---|---|---|
| 10 SAW | 13.00 | .5 | 4 | | 34 |
| 20 DEBURR | 8.00 | .25 | 10 | | 25 |
| 30 DRILL | 12.00 | .25 | 5 | | 20 |
| | | | | | |
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JobBOSS
SOFTWARE
WE'RE PART OF YOUR SHOP
ISO 9000 CERTIFIED

## JobBOSS Sample Job Form

Your Name: BoB
Your Company's Name: SER
Phone #: ( ) ____ - ______
Fax #: ( ) ____ - ______

Job #: 9519-E
Part #: 9519-15
Description: ANGLE END
Selling Price: —
Run Quantity or Quantities: 1
Shop Rate or Labor/Burden: 25%

Type of Material: (Indicate if Purchased Direct or from Inventory)

| | | |
|---|---|---|
| | ANGLE 2×2×1/4 ×18" | Cost: 1.20 |
| | FROM INVENTORY | Cost: |
| Subcontract SVC: | | Cost: |
| | | Cost: |
| | | Cost: |
| | | Cost: |
| Other: | | Cost: |
| | | Cost: |

### Routing

List sequence of operations and their estimated and actual run times. If you do not use routings, indicate the total time of the job.

**Circle One:** Parts/Hour Sec/Part Min/Part Hours/Piece

| Operation | Shop Rate | PER JOB Setup Hours | PER PART Estimated Run Time | Actual Run Time or | PER PART Total Time |
|---|---|---|---|---|---|
| 10 BSAW | 13.00 | .5 | 4 | | 34 |
| 20 DEBURR | 8.00 | .25 | 10 | | 25 |
| 30 MILL | 14.00 | .5 | 20 | | 40 |
| | | | | | |
| | | | | | |
| | | | | | |

ISO 9000 CERTIFIED

## JobBOSS Sample Job Form

Your Name: BOB

Your Company's Name: SER

Phone #: ( ) ____ - ______

Fax #: ( ) ____ - ______

Job #: 9519-F

Part #: NUT 7/8 NC

Description: NYLOCK NUT 7/8 NC

Selling Price: —

Run Quantity or Quantities: 16

Shop Rate or Labor/Burden: —

Type of Material: (Indicate if Purchased Direct or from Inventory)

NYLOCK NUT 7/8 NC Cost: $0.39 EACH

PURCHASED DIRECT Cost: ______

Subcontract SVC: ______ Cost: ______

______ Cost: ______

______ Cost: ______

______ Cost: ______

Other: THIS IS A PURCHASE ITEM Cost: ______

PURCHASED SPECIFICALLY FOR Cost: ______

THIS JOB 9519

**Routing**

List sequence of operations and their estimated and actual run times. If you do not use routings, indicate the total time of the job.

**Circle One:** Parts/Hour Sec/Part Min/Part Hours/Piece

| Operation | Shop Rate | Setup Hours | Estimated Run Time | Actual Run Time or | Total Time |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
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| | | | | | |

8/07/95
10:57 AM

Estimate Cost - Assembly Recap

Estimate # 1073 Date 8/07/95

| Customer | Part Number | Rev | Description |
|---|---|---|---|
| ABC COMPANY | 9519ASSY | | BRIDGE ASSEMBLY |

| Quantity | 1 | 3 | 5 | 10 |
|---|---|---|---|---|
| Cost: | | | | |
| 1073 BRIDGE ASS 9519ASSY | 117.29 | 257.49 | 397.68 | 748.18 |
| 1073-A J CHANNEL 9519-1 | 95.11 | 247.06 | 399.00 | 778.88 |
| 1073-B WIDE FLANG 9519-2 | 244.24 | 680.97 | 1,117.69 | 2,209.51 |
| 1073-C ANGLE BRAC 9519-3 | 42.28 | 75.08 | 107.88 | 189.88 |
| 1073-D ANGLE BRAC 9519-14 | 35.28 | 54.08 | 72.88 | 119.88 |
| 1073-E ANGLE END 9519-15 | 51.53 | 84.83 | 118.13 | 201.38 |
| Total Cost | 585.73 | 1,399.51 | 2,213.26 | 4,247.71 |
| Cost/ E | 585.73 | 466.50 | 442.65 | 424.77 |
| Markup | 86.15 | 222.69 | 359.22 | 700.56 |
| Subtotal | 671.88 | 1,622.20 | 2,572.48 | 4,948.27 |
| Price/E | 671.88 | 540.73 | 514.50 | 494.83 |
| Misc Charges | .00 | .00 | .00 | .00 |
| Total Price | 671.88 | 1,622.20 | 2,572.48 | 4,948.27 |
| Profit % | 13% | 14% | 14% | 14% |
| Total Hours | 11.28 | 20.30 | 29.32 | 51.93 |
| Hours/Part | 11.28000 | 6.76666 | 5.86400 | 5.19300 |

8/07/95
10:58 AM

Estimate Audit

Estimate # 1073
Estimate Date 8/07/95
Customer ABC COMPANY
Part # 9S19ASSY
Description BRIDGE ASSEMBLY
Reference

Type A
Rev
UM E

| Estimated Quantity | Start Quantity | Estimated Price/E | Quoted Price/E | - - - - - Markup % - - - - Labor | Inv | Dir Buy/ Subcontr |
|---|---|---|---|---|---|---|
| 1 | 1 | 671.88 | 671.88 | 10 | 10 | 20 |
| 3 | 3 | 540.73 | 540.73 | 10 | 10 | 20 |
| 5 | 5 | 514.50 | 514.50 | 10 | 10 | 20 |
| 10 | 10 | 494.83 | 494.83 | 10 | 10 | 20 |

- - - - - - - - - - - R O U T I N G - - - - - - - - - - -

| Ln# | WC-OP | WC Desc | Operation Desc | Setup | Min/Part | Eff | Run/Each | Yld |
|---|---|---|---|---|---|---|---|---|
| 010 | 98-010 | FAB | | .50 | 60.00 | 00 | 1.00000 | |
| 020 | 83-020 | WELD | | .25 | 45.00 | 00 | .75000 | |
| 030 | 34-030 | CLEAN | | .25 | 10.00 | 00 | .16667 | |
| 040 | 09-040 | INSPECT | | .25 | 10.00 | 00 | .16667 | |
| 050 | 20-050 | SHIP | | .50 | 10.00 | 00 | .16667 | |

- - - - - - - D I R E C T B U Y & S U B C O N T R A C T - - - - - -

| Ln | Parts/Item | Items/Part | Qty 1 | 3 | 5 | 10 |
|---|---|---|---|---|---|---|
| 010 | | 1.000 Unit/E: | .39 | .39 | .39 | .39 |
| ATS | NYLOCK NUT 7/8 NC | | .39 | 1.17 | 1.95 | 3.90 |

8/07/95
11:00 AM

Shop Paper
Job # 1360

Part #: 9519ASSY
Desc: BRIDGE ASSEMBLY
Order Qty: 5
Release Qty: 5

Rev:

PO #: 1234124
Order Date: 8/07/95
Order Type: A
Est Hours: 13.00

Cust #: ABC

Ship To #:
Ship Via: BEST WAY

- - - - - - - - - D E L I V E R Y S C H E D U L E - - - - - - - -

| Due Date | Quantity | Comment |
|---|---|---|
| 9/15/95 | 3 | |
| 9/30/95 | 2 | FINAL SHIPMENT |

- - - - - - - - - - - - - R O U T I N G - - - - - - - - - - -

| WC-Op | Start | Stop | WC Desc | Operation Description | Setup | Min/Part | Run |
|---|---|---|---|---|---|---|---|
| 98-010 | 9/14 | 9/14 | FAB | | .50 | 60.00 | 5.00 |
| 83-020 | 9/14 | 9/15 | WELD | | .25 | 45.00 | 3.75 |
| 34-030 | 9/15 | 9/15 | CLEAN | | .25 | 10.00 | .83 |
| 09-040 | 9/15 | 9/15 | INSPECT | | .25 | 10.00 | .83 |
| 20-050 | 9/15 | 9/15 | SHIP | | .50 | 10.00 | .83 |

- - - - - - - D I R E C T B U Y & S U B C O N T R A C T - - - - - -

| Ln | PO # | Vendor Name | Description | Quantity | Due Date |
|---|---|---|---|---|---|
| 010 | | A.T.S. STEELS, INC. | NYLOCK NUT 7/8 NC | 5 | 0/00/00 |

YOUR NAME AND
LOGO GO HERE

QUOTATION

NUMBER 1073 DATE 8/07/95

TO
ABC COMPANY
123 SECOND ST
VAN NUYS CA 91504

SHIP TO

| TERMS | SHIP VIA | SALESPERSON | PAGE |
|---|---|---|---|
| NET 30 DAYS | | | 1 |

| QUANTITY | DESCRIPTION | UNIT PRICE | AMOUNT |
|---|---|---|---|
| | IN REPLY TO YOUR INQUIRY WE ARE PLEASED TO QUOTE AS FOLLOWS: | | |
| | Part # 9519ASSY<br>BRIDGE ASSEMBLY | | |
| 1 | | 671.88 | 671.88 |
| 3 | | 540.73 | 1,622.19 |
| 5 | | 514.50 | 2,572.50 |
| 10 | | 494.83 | 4,948.30 |
| | PLEASE CALL RICH HANSON IF YOU HAVE ANY QUESTIONS AT 1-800-777-4334. | | |

11:02 AM

Part #: 9519ASSY    Rev:    PO #: 1234124
Desc: BRIDGE ASSEMBLY    Order Date: 8/07/95
Order Qty: 5

Cust #: ABC    Phone:
ABC COMPANY    Fax:

------------------- D E L I V E R Y   S C H E D U L E -------------------

| Date | Qty Due | Qty Shipped | Comment |
|---|---|---|---|
| 9/15/95 | 3 | | |
| 9/30/95 | 2 | | FINAL SHIPMENT |

---------------------- C O M P O N E N T   L I S T ----------------------

| Job # | Part Number | Rev | Description | Stat | Rel Qty | Est Hrs | Act Hrs |
|---|---|---|---|---|---|---|---|
| 1360 | 9519ASSY | | BRIDGE ASSEMBLY | | 5 | 13 | 0 |
| 1360-A | 9519-1 | | J CHANNEL | | 5 | 2 | 1 |
| 1360-B | 9519-2 | | WIDE FLANGE BRACKET | | 5 | 4 | 0 |
| 1360-C | 9519-3 | | ANGLE BRACE | | 10 | 4 | 0 |
| 1360-D | 9519-14 | | ANGLE BRACKET | | 5 | 3 | 0 |
| 1360-E | 9519-15 | | ANGLE END | | 5 | 4 | 0 |
| | | | | Total | | 30 | 1 |

------------------- W O R K   C E N T E R   R E C A P -------------------

| Work Center | Est Hrs | Act Hrs |
|---|---|---|
| 09 INSPECT | 1 | 0 |
| 13 DEBURR | 6 | 0 |
| 19 CNC MILL | 2 | 0 |
| 20 SHIP | 1 | 0 |
| 25 DRILL | 2 | 0 |
| 34 CLEAN | 1 | 0 |
| 39 B SAW | 6 | 1 |
| 83 WELD | 4 | 0 |
| 98 FAB | 6 | 0 |

-------------- I N V E N T O R Y   R E Q U I R E M E N T S --------------

| Job # | Item # | Description | Units | Due Date | Est Qty | Act Qty |
|---|---|---|---|---|---|---|
| 1360-C | ANG2X2X1/4X14 | ANGLE 2X2X1/4X14 | EA | 0/00/00 | 10 | 0 |
| 1360-D | ANG2X2X1/4X32 | ANGLE 2X2X1/4X32" | EA | 0/00/00 | 5 | 0 |
| 1360-E | ANG2X2X1/4X18 | ANGLE 2X2X1/4X18 | EA | 0/00/00 | 5 | 0 |

------------- D I R E C T   B U Y   &   S U B C O N T R A C T -------------

| Job # | Vendor | Description | Due Date | Est Qty | Act Qty |
|---|---|---|---|---|---|
| 1360 | A.T.S. STEELS, INC. | NYLOCK NUT 7/8 NC | 0/00/00 | 5 | 0 |
| 1360-A | ABLE STEEL SUPPLY | J CHANNEL 10X6.5 | 9/10/95 | 5 | 0 |
| 1360-A | BAKER TREATING & PLATIN | HEAT TREAT | 0/00/00 | 5 | 0 |
| 1360-B | ABLE STEEL SUPPLY | WIDE FLANGE | 9/10/95 | 5 | 0 |

8/07/95
11:00 AM

Shop Paper
Job # 1360

Part #: 9519ASSY
Desc: BRIDGE ASSEMBLY
Order Qty: 5
Release Qty: 5

Rev:

PO #: 1234124
Order Date: 8/07/95
Order Type: A
Est Hours: 13.00

Cust #: ABC

Ship To #:
Ship Via: BEST WAY

- - - - - - - - D E L I V E R Y S C H E D U L E - - - - - - - -

| Due Date | Quantity | Comment |
|---|---|---|
| 9/15/95 | 3 | |
| 9/30/95 | 2 | FINAL SHIPMENT |

- - - - - - - - - - - R O U T I N G - - - - - - - - - - - -

| WC-Op | Start | Stop | WC Desc | Operation Description | Setup | Min/Part | Run | INSPECTION COMMENTS: | EMPLOYEE |
|---|---|---|---|---|---|---|---|---|---|
| 98-010 | 9/14 | 9/14 | FAB | | .50 | 60.00 | 5.00 | | |
| 83-020 | 9/14 | 9/15 | WELD | | .25 | 45.00 | 3.75 | | |
| 34-030 | 9/15 | 9/15 | CLEAN | | .25 | 10.00 | .83 | | |
| 09-040 | 9/15 | 9/15 | INSPECT | | .25 | 10.00 | .83 | | |
| 20-050 | 9/15 | 9/15 | SHIP | | .50 | 10.00 | .83 | | |

- - - - - - - D I R E C T B U Y & S U B C O N T R A C T - - - - -

| Ln | PO # | Vendor Name | Description | Quantity | Due Date |
|---|---|---|---|---|---|
| 010 | | A.T.S. STEELS, INC. | NYLOCK NUT 7/8 NC | 5 | 0/00/00 |

8/07/95
11:00 AM

Assembly Graph - Job 1360

Customer: ABC
ABC COMPANY

Part #. 9519ASSY
BRIDGE ASSEMBLY

Rev.

Ord Date. 8/07/95
Del Date: 9/15/95

| Job # | Start | Stop | DAY 1 2 3 4 5<br>12345678901234567890123456789012345678901234567890 12 | Description | Part Number |
|---|---|---|---|---|---|
| 1360-A | 9/08/95 | 9/08/95 | :: | J CHANNEL | 9519-1 |
| 1360-B | 9/08/95 | 9/11/95 | :::::::: | WIDE FLANGE BRACKET | 9519-2 |
| 1360-C | 9/11/95 | 9/12/95 | :::: | ANGLE BRACE | 9519-3 |
| 1360-D | 9/11/95 | 9/12/95 | :::: | ANGLE BRACKET | 9519-14 |
| 1360-E | 9/12/95 | 9/12/95 | :: | ANGLE END | 9519-15 |
| 1360 | 9/14/95 | 9/15/55 | :::: | BRIDGE ASSEMBLY | 9519ASSY |

8/07/95
11.02 AM

Cost Summary - Assembly Job 1360
Excluding Transfers to Finished Goods

| Cust # | Name | Ord Date | Price | Ordered | Shipped | Tran |
|---|---|---|---|---|---|---|
| ABC | ABC COMPANY | 8/07/95 | $14.50/E | 5 | | |

| | | -- Quantity -- | | ---- Hours ---- | | ----- Cost ----- | | ---------------- Actual Cost ---------------- | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Job # | Part | Order | Prod | Est | Act | Est | Act | Labor | Burden | Inventory | Dir Buy |
| 1360 | BRIDGE ASSEMBLY | 5 | | 13.00 | .00 | 398 | | .00 | .00 | .00 | .00 |
| 9519ASSY | Rev | | | | | | | | | | |
| 1360-A | J CHANNEL | 5 | 5 | 2.00 | 1.20 | 399 | 32 | 14.10 | 17.63 | .00 | .00 |
| 9519-1 | Rev | | | | | | | | | | |
| 1360-B | WIDE FLANGE BRACKE | 5 | | 3.50 | .00 | 1,118 | | .00 | .00 | .00 | .00 |
| 9519-2 | Rev | | | | | | | | | | |
| 1360-C | ANGLE BRACE | 10 | | 4.17 | .00 | 108 | | .00 | .00 | .00 | .00 |
| 9519-3 | Rev | | | | | | | | | | |
| 1360-D | ANGLE BRACKET | 5 | | 2.58 | .00 | 73 | | .00 | .00 | .00 | .00 |
| 9519-14 | Rev | | | | | | | | | | |
| 1360-E | ANGLE END | 5 | | 4.08 | .00 | 118 | | .00 | .00 | .00 | .00 |
| 9519-15 | Rev | | | | | | | | | | |
| | | Assembly Total | | 29.33 | 1.20 | 2,214 | 32 | 14.10 | 17.63 | .00 | .00 |

| | | | | | |
|---|---|---|---|---|---|
| Prod Sales | .00 | Cost /E | .00 | Profit | 32.00- |
| Misc Charges | .00 | Profit/E | .00 | Profit % | .00 |

YOUR NAME AND
LOGO GO HERE

PURCHASE ORDER

| NUMBER | DATE |
|---|---|
| 1229 | 8/07/95 |

TO
ABLE STEEL SUPPLY
3445 RANDOLPH
ST PAUL MN 55487

SHIP TO

PH 612/234-9983 FAX 234-9876

| TERMS | SHIP VIA | SALESPERSON | PAGE |
|---|---|---|---|
| 2.00% 10 Net 30 F.O.B. Origin | UPS | | 1 |

| QUANTITY | DESCRIPTION | UNIT PRICE | AMOUNT |
|---|---|---|---|
| 5 | EA J CHANNEL 10X6.5<br>Job: 1360-A Due Date: 9/10/95 | 54.60 | 273.00 |
| 5 | EA WIDE FLANGE<br>Job: 1360-B Due Date: 9/10/95<br>14 X 22 # 38 FT. | 205.80 | 1,029.00 |
| | Order total | | 1,302.00 |
| | PLEASE CALL RICH HANSON WITH ANY QUESTIONS. | | |

8/07/95
11:03 AM

Projected Job Cost - 1360-A

| Part Description | Customer | | Price | Ord Date |
|---|---|---|---|---|
| J CHANNEL | ABC | ABC COMPANY | .00/ | 8/07/95 |
| 9519-1 | Ord Qty: | 5 | | |

| - - - - - - - - - - LABOR - - - - - - - - - | | | | | Estimate | Actual | Projected |
|---|---|---|---|---|---|---|---|
| | Setup Hrs | | Run Hrs | | | | |
| WC-OP | Estimate | Actual | Estimate | Actual | | | |
| 39-010 | .50 | .40 | .83 | .50 | 17.33 | 11.70 | 11.70 |
| 13-020 | .25 | .20 | .41 | .10 | 5.33 | 2.40 | 3.60 |
| Total | .75 | .60 | 1.24 | .60 | ---------- | ---------- | ---------- |
| | | | | Total | 22.66 | 14.10 | 15.30 |
| | | | | Per Hour | 11.39 | 11.75 | 11.33 |

| - - PRODUCTION - - - | | | - - - BURDEN - - - | | | | |
|---|---|---|---|---|---|---|---|
| S | Qty Run | Scrap | WC-OP | WC Desc | | | |
| C | 5 | | 39-010 | B SAW | 21.67 | 14.63 | 14.63 |
| | 2 | | 13-020 | DEBURR | 6.67 | 3.00 | 4.50 |
| | | | | | ---------- | ---------- | ---------- |
| | | | | Total | 28.34 | 17.63 | 19.13 |
| | | | | Per Hour | 14.24 | 14.69 | 14.17 |

| - - - - DIRECT BUY / SUBCONTRACT - - - - | | | | | | |
|---|---|---|---|---|---|---|
| S | Item Description | Est Qty | Act Qty | | | |
| O | J CHANNEL 10X6.5 | 5 | 0 | 273.00 | .00 | 273.00 |
| | HEAT TREAT | 5 | 0 | 75.00 | .00 | 75.00 |
| | | | | ---------- | ---------- | ---------- |
| | | | Total | 348.00 | .00 | 348.00 |

| | | | | | |
|---|---|---|---|---|---|
| Production Count | 5 | Total Cost | 399.00 | 31.73 | 382.43 |
| | | Cost/ | 79.80 | 6.35 | 76.49 |